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"Student"

On the 16th October, 1937, at the age of 61, Mr. W. S. Gossett, Chief Brewer to the firm of Messrs. Arthur Guinness, Son & Co., of Dublin, passed away. Under the pseudonym of " Student ", by which he was known throughout the world of agricultural science, Mr. Gossett in his lifetime published statistical papers which so profoundly influenced the whole development of agricultural experimentation that it is fitting that we should review for a moment the fundamental nature of his contributions, so that we may pay, in our turn, tribute to him on his passing.

Although primarily chemist and mathematician, Mr. Gossett early recognised the importance of mathematical statistics to the industrial and practical problems of his world, and sought continually to put to practical use the statistical theories so largely developed by Professor Karl Pearson. From

the industrial point of view, his success may be gauged by the confidence with which his employers placed their commercial operations under his statistical control. His contribution to agricultural statistics will likewise merit lasting recognition, and every student of experimental method should be familiar with his work.

Following his first paper in 1907 on applied bacteriology and its relationship to the Poisson distribution, which appeared in *Biometrika*, " Student " published in 1908 in the same journal his fundamental contribution : " On the Probable Error of a Mean ". In this paper, he showed his keen appreciation of the practical point of view by realising that most agricultural experiments would be concerned with small numbers to which the then known statistical laws based on large numbers did not apply. He demonstrated that in the " test of significance ", the distribution of the ratio " z " ($=x/s$, where x=difference and s=error) did not obey the normal law of frequency when the numbers in each sample were small, and then gave the appropriate distribution. Not only was the paper valuable in itself, but it unquestionably led to further study by R. A. Fisher on small sample theory, on the basis of which present day tests of significance are based.

A few years later, " Student " became associated with E. S. Beaven in his work of testing barley varieties ; together they developed the familiar Half-Drill Strip method of testing varieties of cereals (*Biometrika*, 1923), which was so much used in earlier agricultural work. In connection also with the practical considerations of his commercial work, " Student " published an important paper on " Errors of Routine Analyses ", which appeared in *Biometrika* in 1927.

He maintained his interest in field experimentation to the very last, as his most recent papers (*Supp. Jour. Roy. Stat. Soc.*, 1936) have shown ; indeed it was only a fortnight before his death that he had completed the draft of his final contribution : " Comparison of Balanced and Random Arrangements of Field Plots " (*Biometrika*, 1938), in which he upheld the practical as against the theoretical advantages in experimental designs.

With his passing, the world has lost one who was the most kindly of men to those who had the opportunity of meeting him—one who had ever foremost in his mind the difficulties which beset those whose work lies in the realm of field experimentation.

Technical Developments and the Journal

The twenty-fourth meeting of the Australian and New Zealand Association for the Advancement of Science, to take place at Canberra within the next few weeks, will hold more than ordinary interest for workers in agricultural science. The holding of this biennial Congress is usually the signal for scientists of all schools to gather together for the purpose of exchanging opinions and ideas, and to enter into the formal discussions on problems in their respective fields of endeavour. But on this occasion, at least so far as agricultural scientists are concerned, the meeting will provide a notable attraction in the presence of its official guests from overseas, included among whom are Sir E. John Russell, of the Rothamsted Experiment Station, Professor F. T. Brooks, of Cambridge University, Professor N. V. Sidgwick, of Oxford, and Professor Ralph Carr, of Purdue University, not to mention Mr. H. G. Wells, the world famous author. The invitation addresses to be delivered by Sir John Russell and Professor Brooks will be awaited with interest, and to those unable to attend the Congress there is some small satisfaction in the fact that the utterances of these distinguished scientists may be widely read when published in the daily Press and in current periodicals.

Immediately preceding the meetings of the A.N.Z.A.A.S., the Second General Meeting of the Institute of Agricultural Science will be held, scheduled to commence on January 9th, at 10 a.m., and to extend over two days. Various business items will have to be dealt with, but sessions have been arranged to meet the needs of discussion on certain professional and scientific subjects. A wide representation of agricultural workers from various States is expected to be in attendance, and the full proceedings of the meeting will later be published in this Journal. An official publication performs varied and useful functions in any professional organisation, and is of particular importance where vast distances preclude the attendance of members at the annual, or even the monthly, meetings of the association concerned. That has been abundantly evident in the case of our own organisation. Obviously, it will be impossible for all affiliated with the Institute to partake of the good things offering in the course of the Canberra meetings next month, but again the Journal will fulfil its customary functions. Indeed, the most effective means of expression that the Institute can offer to workers in agricultural science, both in Australia and overseas, is through the pages of its official publication. Naturally, the Journal is valued by many Australians as a record of local events and happenings ; but an important function is to supply a cogent review of current research in agriculture for the information of readers both locally and abroad. The need for such a review has been keenly felt for some considerable time, and it is evident that there is now an opportunity to supply this need to an ever widening circle. With the recent popularisation of the

Australian departmental journals and their proper adaptation to the requirements of practical agriculturalists, this Journal tends to become the focal point for scientific information relating to the progress of Australian research in agriculture. Officers of the C.S.I.R. and of the various Departments of Agriculture are naturally expected to contribute the results of most of their investigations in the publications of their own particular organisations; but there is good reason for placing on record in this Journal notices of work in progress, technical advances and preliminary results of researches.

The Journal caters for contributions of three distinct types. Articles of the review type, dealing with completed local or overseas work, are acceptable as "General Articles". Data of a technical character, giving preliminary notices of completed or partially completed investigational work, are suitable for publication as "Technical Notes". Finally, in the section "Current Notes and News", space is available for the recording of new projects, the progress of experimental work, and the development of particular research programmes. The Journal thus provides a unique opportunity for the contemporary review of Australian research in agriculture. Many investigators, it may be argued, are unwilling to disclose results of their discoveries until the time has arrived for the publication of a final pronouncement; but conditions have changed rapidly in the last decade, and with the growing impossibility and inadvisability of cloistered research in agricultural problems, it becomes more and more difficult for progress results to be hidden from the general view. The obvious means by which the investigator can secure priority for his discoveries, and at the same time render a distinct service to his profession, is by the contribution of brief notes, as technical notes, on his researches, to be published under his own name. Numerous cases could be cited in which an author has lost the priority due to him, or has been forced to enter a somewhat degrading controversy, because no early record was made of the major finding prior to its discovery by others.

Through the two sections, "Technical Notes" and "Current Notes and News", a full expression can be made of current work throughout Australia, and it is the fervent hope of the Editorial Committee that members will still more avail themselves of the opportunity provided by contributing freely through their State branches.

Plant Hormones

By

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The increasing attention paid within recent years to plant hormones is evidenced by the number of research papers, review articles and other publications, including three books[2, 11, 24] on the subject. General interest in plant hormones has been aroused not only because the research work so far accomplished has been of value in explaining some of the fundamental growth processes of plants, but also because the subject affords an example of a case where research in pure plant physiology has produced something of definite value for the practical horticulturist and agriculturist.

The definition of hormone as given by Went and Thimann[24] is: "A hormone is a substance which, being produced in any one part of the organism, is transferred to another part and there influences a specific physiological process." Perhaps the simplest definition of a hormone is that it is a "chemical messenger" produced in one part of an organism and carried to another part where its effect is exerted. Other terms which have been employed for plant hormone or phyto-hormone are growth substance, growth regulator, growth hormone, Wuchstoff and auxin. The terms, growth substance and growth regulator, are somewhat non-committal and may be applied to substances which, strictly speaking, cannot be referred to as hormones. Wuchstoff has been used for some of the growth substances of yeasts and fungi. The term auxin, which was first suggested by Kögl and Haagen Smit,[10] is usually restricted to those substances which cause a curvature response in *Avena* coleoptiles.

It is generally agreed that credit for the first complete theory embodying the essential features of the action of plant hormones must be given to Sachs,[15] who, slightly more than fifty years ago, explained morphological differences in plants as due to special organ-forming substances which moved in different directions through a plant, influencing the development of leaves, stems, flowers, roots, etc. The work of Darwin,[5] Paal,[13, 14] Boysen Jensen,[1] Fitting[6] and others on phototropism laid the foundation of the modern concept of plant hormones. Went and Thimann[24] have pointed out that four apparently independent lines of plant physiology, namely organ formation, correlation, tropisms and growth, have been gradually brought together by the discovery of the functions of plant hormones. Consequently, it is necessary to remember that workers in many branches of plant science have contributed to our present knowledge of these substances.

Methods of Determining Plant Hormones.

The investigational work on plant hormones has been dependent on physiological methods of testing for them. The most important of these has been the *Avena* test, which is based on the increase in length of the coleoptile or sheath surrounding the first leaves of a germinating oat seedling. Other methods of testing plant hormones include the measurement of the bending of split pea stems placed in test solutions, the measurement of epinastic responses (especially of stems), the inhibition of lateral bud development, the formation of roots on cuttings and the production of swellings on stems.

It has been known for a long time that plant parts such as stems, petioles, flower stalks and coleoptiles stop growing if the apical parts are cut off. Paal[14] was the first to show that this is not due to a simple wound shock, for if the tip of a decapitated coleoptile is replaced on the cut surface the coleoptile will resume growth. Boysen Jensen[1] showed that the excised tip could still exert its effect if a thin layer of gelatin were placed between the tip and the stump. Thus it was apparent that the tip exerted its influence by means of some substance which could diffuse through gelatin. Went[21] showed that if a coleoptile tip is placed for a time on agar or gelatin, and the agar or gelatin is then placed on the stump, growth is resumed in the same way as when the tip itself is replaced. Apparently, therefore, the substance stimulating growth diffused from the coleoptile tip into the agar, since pieces of untreated agar had no influence on a decapitated stump. Further investigations showed that if an excised coleoptile tip or a piece of agar on which such a tip had been placed for a few hours were placed on one side of the stump, then the latter would bend away from the side which had been treated. This was interpreted as being due to the action of the growth substance in increasing the length of the coleoptile on the side on which it was placed.

If environmental conditions can be maintained constant, then the amount of bending, i.e. the angle of bending away from the vertical, in a given time is related to the amount of growth substance applied. This is the basis of what has undoubtedly been the most important quantitative method of determining plant growth substances. As a quantitative method, it is usual to carry out the work under conditions of constant temperature and humidity in the dark, using red or orange light for manipulations. In qualitative work, it is often possible to carry out the work in the light. The *Avena* technique, with various modifications, has been described in detail by Went and Thimann.[24]

Of the other methods of determining the growth-promoting properties of substances, perhaps the most useful is the pea test designed by Went.[22] This depends on the fact that if a growing stem is split longitudinally and placed in a solution of growth substance, then there is an inward curving of the two halves, but if placed in water then the two halves curve outwards.

The Chemical Nature of Plant Hormones.

Seubert,[16] who was the first to show that growth substances occur outside the plant, found that malt extract, saliva, diastase and pepsin contained a substance active in causing *Avena* curvatures. Nielsen[12] showed that the medium on which *Rhizopus suinus* and *Absidia ramosa* had grown was rich in a substance active in producing this phenomenon. Similar results were secured by other workers using the same and other species of *Rhizopus*. Kögl and Haagen Smit[10] found an active substance present in large quantities in human urine. Purification of this material yielded crystals of an acid, auxentriolic acid ($C_{18}H_{32}O_5$) which was named auxin *a*. Another active substance was isolated from malt and from corn germ oil by Kögl, Erxleben and Haagen Smit.[9] This substance, auxenolonic acid ($C_{18}H_{30}O_4$), which has the same physiological activity as auxin *a*, was named auxin *b*. The same workers later isolated another active substance from urine. This proved to be indole-3-acetic acid ($C_{10}H_9O_2N$) and was named heteroauxin. Thimann[18] investigated the active material obtained from *Rhizopus* cultures by Nielsen[12] and decided that it was almost certainly heteroauxin.

Since the discovery of auxin *a*, auxin *b* and heteroauxin as active growth substances, numerous other chemicals have been tested for their ability to influence growth processes. Most of those which have any activity are derivatives of indole-3-acetic acid or substances closely related to this compound. Commercial tryptophane is slightly active but recrystallisation shows that its activity is apparently due to impurities. However, if the recrystallised tryptophane is used in the *Avena* test, slight curvatures are produced after a lapse of a few hours. Tryptamine behaves in the same way. It is known that tryptophane may be acted on by bacteria and fungi to give indole-3-acetic acid, and it is thought that both tryptophane and tryptamine may be changed to indole-3-acetic acid by the action of plant enzymes. Tryptophane and tryptamine are therefore of special interest as being examples of substances which could act as precursors to the formation of hormones in the plant.

The principal growth substance formed by all of the higher green plants is thought to be the same, and to be auxin *a*, although the final proof can only be given, of course, by the isolation and chemical identification of the native plant hormone. The evidence so far available is based on molecular weight determinations and on the sensitivity of the substance to acids and alkali. The molecular weight has been determined by the diffusion method with agar blocks which are used in the *Avena* test before and after diffusion.

Occurrence in the Plant.

There are two main methods of obtaining hormone from plant parts. The method most frequently employed is that of allowing the auxin to diffuse out into water, or into an aqueous gel in the preparation of which agar is usually

employed. The other method, by which smaller amounts can be detected, is to extract the plant tissue directly with a solvent such as water, ether, alcohol or chloroform. Extraction with water usually leads to inactivation by oxidising enzymes so that it has been found better to use one of the other solvents suitably treated to free it from peroxidase, chlorine and other oxidising agents.

Much work has been conducted to determine the amounts of growth substance in various parts of plants. It has been found that there is a distinct correlation between the position of an organ and its auxin production. Only the most apical regions form auxin, and the more terminal their position the greater their production. In addition to being present in the producing zones, auxin is also distributed throughout other parts of the plant. Thimann,[17] for example, found that auxin is present everywhere in an oat seedling and that the concentration decreased with increasing distance from the coleoptile tip.

Hormones and Root Growth.

Unlike shoots in which decapitation reduces the growth rate, the decapitation of roots does not have very much effect on their growth. Much investigational work was devoted to ascertaining whether removal of the root tip retards or increases the growth of the root, but it remained for Cholodny[3, 4] in 1924 and subsequent years to show conclusively that there is a slight acceleration in root growth if the tip is cut off. This has been explained as due to the removal of auxin in the excised tip, and to the fact that in roots auxin retards root elongation. However, it has been found that the application of extremely small amounts (in the vicinity of 10^{-9} mol.) of indole acetic acid causes slight but definite growth promotion. Higher concentrations inhibit growth.

The work of several investigators has been directed towards determining whether auxin is produced in the root tip or whether it merely accumulates there. The concensus of opinion is that under certain circumstances the root tip may produce auxin, but that in any case the amount is very small compared with that produced by the apical portions of above-ground parts. The mechanism by which auxin inhibits root elongation has not yet been definitely elucidated.

It is a well-recognised fact that it is much easier to secure the promotion of roots on stem cuttings if buds are present. In fact, removal of the buds from such cuttings stops root formation almost completely. Leaves on cuttings are also effective, but not as effective as buds, in aiding root formation. The conclusions drawn from an immense amount of work on the effect of growth hormones on root formation are that buds and leaves owe their ability to promote root formation on cuttings to their production of a hormone, probably auxin *a*.

Many workers have been able to induce roots to develop from stems and petioles by the application of lanolin preparations containing hormones. The

soaking of cuttings in solutions of hormones, the addition of hormones to the soil in which cuttings are placed, and injection into the stems have all been used to promote root formation.

The ability of hormones to stimulate root formation on cuttings has been made use of in horticulture. The usual procedure is to place the cuttings in a very dilute solution of the growth substance for 12 to 24 hours. A solution containing one part by weight of the pure chemical in from 10,000 to 50,000 parts by weight of water usually gives good results, although the optimum strength of the solution varies somewhat with different species of plants. After removal from the solution, the cuttings are placed in soil and treated in the same way as ordinary cuttings on which it is desired to induce rooting. The main beneficial effects of the use of plant growth substances are : (1) a higher percentage of cuttings form roots ; (2) the root systems are more profuse and a greater number of roots are formed ; and (3) the rooting process is accelerated. Cuttings of certain plants which form roots with difficulty or not at all, can be induced to root relatively easily by the use of growth substances, but cuttings of some plants cannot be induced to root, even by the use of growth substances. Substances which at present appear most likely to be of value in commercial work are phenyl acetic acid, alpha naphthalene acetic acid, indole-3-acetic acid and indole-3-butyric acid. These and many other chemicals have been investigated for their ability to stimulate root formation by Hitchcock and Zimmerman[8] in America and Tincker[19, 20] in England.

Tropisms.

It has been mentioned that the study of tropisms, particularly of phototropism, was responsible for some of the earlier evidence on the existence and function of hormones in plants. Prior to the development of the present hormone concept, many elaborate theories had been advanced to explain geotropism, phototropism and other tropistic responses of plants. The Cholodny-Went theory is now generally accepted to explain plant tropisms. As given by Went and Thimann[24] it is :

" Growth curvatures, whether induced by internal or external factors, are due to an unequal distribution of auxin between the two sides of the curving organ. In the tropisms induced by light and gravity, the unequal auxin distribution is brought about by a transverse polarization of the cells, which results in lateral transport of the auxin."

It has been shown that, if an oat seedling is placed so that the stem is horizontal instead of vertical, then there is a diffusion of growth substance from the upper to the lower half of the coleoptile. This differential distribution of auxin results in a bending upwards of the coleoptile. Geotropic responses of all above-ground parts can apparently be explained in a similar manner.

Although the investigation of geotropism in the case of roots has offered greater difficulties than in the case of stems, mainly because of smaller quantities of auxin in roots, it seems that there is a diffusion of auxin, as in stems, to the

lower half of a root placed horizontally. Because auxin inhibits root growth, there is a greater growth of the upper part of the root and a consequent downward curving of the root.

Several theories, some of which depend on electric potentials within the plant, have been put forward to explain how auxin becomes redistributed under the influence of gravity, but none of them seems sufficiently convincing.

It has been shown for *Avena* coleoptiles that light may influence the distribution of auxin, which in turn influences growth movements, but just how light can produce an asymmetrical distribution of auxin has not yet been satisfactorily shown.

There is evidence that other tropistic movements in plants, such as traumatotropism (curvature to or away from wounds) and electrotropism, are dependent on the distribution of auxin in the plant.

Bud Inhibition.

It is well known that lateral buds low down on a stem and which do not develop in the presence of a terminal bud, usually grow out as soon as the terminal branch or bud is removed. This is utilised in pruning. The investigations of several workers showed that the inhibitory effect was apparently due to some substance transported from the terminal bud and that this inhibitory effect could be duplicated by keeping blocks of agar containing one of the recognised plant hormones on a decapitated stem in place of the terminal bud. The evidence seems fairly conclusive that bud inhibition actually is brought about by auxin diffusing from the terminal bud.

Conclusions.

It has been possible in this brief review to refer only to some of the growth processes and responses of plants which have been shown to be affected by hormones. Our knowledge of these substances is far from complete but thanks to the efforts of a large band of research workers in many countries, additional knowledge is continually becoming available.

So far, hormones have been used in horticulture and agriculture mainly for the stimulation of root formation on cuttings, but work such as that of Grace[7] in Canada on the application of growth substances to seeds and to growing plants suggests that there are distinct possibilities in an extension of the commercial use of plant hormones. The fact that plant growth substances occur in relatively large quantities in animal excrements and that certain micro-organisms can produce them may help to explain some of the beneficial effects on plant growth from the use of farmyard and other organic manures.

Plant hormones not only promote growth and the formation of organs but, under certain circumstances, they may also restrict growth, as in the case of their inhibiting effect on root elongation and on lateral bud development.

They appear to control some master reaction within the plant cell, but the mechanism by which their effect is executed is still very obscure.

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The Development of Grasslands

Summary of Address by Dr. A. E. V. Richardson to the Queensland Branch of the Institute on September 30, 1938.

On the basis of average total annual rainfall, the continent of Australia may be divided roughly into three areas :

(1) A central portion, aggregating about one million square miles, with a very erratic rainfall averaging less than 10 inches per annum.

(2) An area of one million square miles experiencing a rainfall of 10 to 20 inches annually.

(3) An outer shell of one million square miles with a rainfall exceeding 20 inches.

Seasonal incidence and reliability of rainfall vary considerably, and this is reflected in pasture type and pasture development. In the south and west, the average rainfall reliability is high—reaching over 90 per cent. in some

areas—and although the rainfall has a marked seasonal incidence it is very efficient because it occurs when evaporation is low. In northern Australia, the rainfall is more erratic and its seasonal incidence is such that its efficiency is lowered by high evaporation rates.

Lines of Development in Southern Areas.

The general course of grassland development in the southern areas has proceeded along five main lines, viz. :

(1) Recognition of the value of superphosphate in raising the carrying capacity of native pastures, largely through stimulation of legume growth.

(2) Extensive exploitation of the surface-sown subterranean clover-superphosphate combination for the purpose of raising carrying capacity. The isolation of regional strains of subterranean clover has assisted this development.

(3) Development of sown pastures, involving the testing of temperate grasses and clovers in various environments. It is now possible to indicate satisfactorily the best mixtures for the various " natural grassland regions " of southern Australia.

(4) Recognition of the value of strain in pasture plants exemplified by the appreciation of certified seed shown by farmers generally.

(5) Improvement in pasture management methods.

Development in Northern Australia.

Work along the following lines is likely to prove profitable in northern Australia :

(1) A survey of the country, with the object of recognising " natural grassland regions ", i.e. regions in which various species and mixtures would exist in equilibrium with the climatic environment. Such a delineation has been proposed for South Australia, the basis being the number of months of the year in which conditions favourable to continuous production occur. The climatic index is Precipitation/Evaporation=0·5. A different index may be required in Queensland.

(2) Determination of the most productive associations of herbage plants for various soil types and climatic regions. In this respect Queensland is unable to draw on any large body of overseas experience, and must depend to a greater extent than the southern States on its own experience. The Plant Introduction Section of the Commonwealth Council for Scientific and Industrial Research is rendering useful assistance.

(3) Improvement of pasture plants by breeding and selection. This is important, not only for the major pasture grasses but also for

leguminous plants in order to make up suitable grass-legume associations. The C.S.I.R. has undertaken work of this nature in Queensland.

(4) Management studies. In the southern States, topdressing presents no difficult problems, response to superphosphate being practically universal. In the north, apparently, there are many problems to be faced. Instances of the effects of methods and time of grazing on productivity and botanical composition of pastures are to be seen in the results obtained at Jealott's Hill (England) and at the Waite Research Institute, South Australia.

(5) Conservation of surplus growth for use in times of nutritional stress.

Council for Scientific and Industrial Research

THE F. D. McMASTER FIELD STATION.

By

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Officer-in-Charge of the Station.

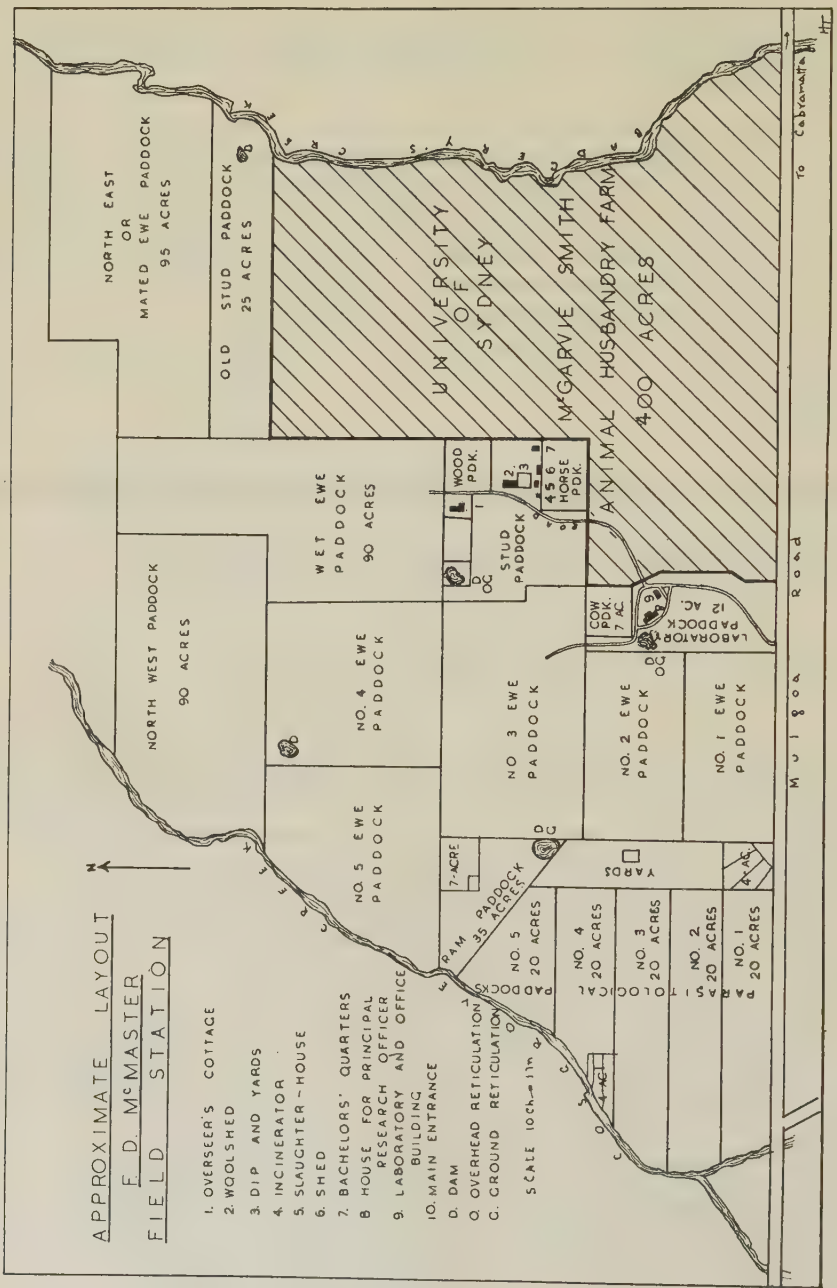
Animal health research cannot be conducted entirely in a laboratory, for it is essential to observe and experiment with groups of domestic animals under controlled field conditions. Further, there are many disadvantages associated with work done either with sheep loaned upon privately owned properties or purchased sheep upon leased country.

For these reasons, the Commonwealth Government, in 1936, purchased 1,256 acres of country from the Buffier Estate. Four hundred of these acres were sold to the University of Sydney and the remainder was improved to suit the needs of a field station.

The property is in the County of Cumberland, approximately 30 miles from Sydney. The country is undulating and originally carried iron-bark, box and stringy-bark timber, sufficient of which remains for shade purposes and to give the rolling country a park-like appearance.

Approximately 1,000 sheep are now depastured upon the available portion of 856 acres after roads, buildings and yard sites have been provided, and it is anticipated that this carrying capacity will be increased by at least 50 per cent. when further subdivision and pasture improvement is effected.

During the developmental period, observations have been in progress. A programme of work was drawn up, therefore, which provided for the excavation of dams, the reticulation of water, the subdivision of the area, the erection



(Block by courtesy of Council for Scientific and Industrial Research.)

of yards, shearing shed, dip and men's quarters, in that order. Later a cottage was erected for the overseer and last of all a residence for the officer-in-charge.

It has been stated that the land was purchased from the Buffier Estate. Actually the greater part of the area had had only two prior owners within the period of land settlement in New South Wales. Upon it some of the very earliest wheat crops of this State were grown, and the late Daniel Buffier had owned and developed it for 50 years prior to his death in 1936. It was thus fitting that his memorial should be a laboratory erected upon the property by his family.

Pasture Improvement.

The second phase of development has been pasture improvement. Already approximately 90 acres have been sown down to permanent pasture of English grasses and clovers. Twelve acres have been sown with lucerne, a further 70 have been scarified, top-dressed with superphosphate and sown with subterranean clover, while 30 have been sown with Rhodes grass and lucerne after similar treatment.

These pastures have done very well, even after the relatively unfavourable autumn of 1938, in which season they were sown. Early plantings were confined to creek frontages; however, quite satisfactory pasture growth was observed upon the higher portions of these paddocks. It is intended, therefore, to sow down approximately 40 additional acres in areas of 5 to 10 acres. These small blocks will be scattered throughout the natural summer growing grass paddocks so that sheep depasturing upon them can have their winter ration supplemented by periodic grazing upon the English grasses.

With regard to the experimental work upon the property, this embraces three principal investigations. Other than these, the staff of the Field Station co-operates with that of the McMaster Laboratory and with research students of the University in such projects as they, as bacteriologists, pathologists or parasitologists, are engaged upon from time to time. In this connection the Field Station has maintained since its inception, approximately 250 adult sheep and given them the prescribed attention.

The specific problems of the Field Station staff are those of fertility in sheep, the inheritance of coloured wool fibres and the inheritance of wrinkles in Merino sheep. Work upon the first of these has already been reported in Bulletin No. 112 of the Council, and now in preparation is a second report which records the observation of seasonal sexual inactivity in Merinos. The other two problems are still in their infancy.

Improved Strains of Lupins, and Their Possible Value in Australia

By

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Lupins have been noted since ancient times for their exceptional ability to grow on infertile, acid, sandy soils, and for the improvement brought about in such soils by their use as green manure. Their usefulness as a fodder crop was, until recently, limited by their unpalatability. The alkaloid content of the plants gave them a bitter taste ; sheep ate the seeds, and sometimes the young growth, but lupins were not otherwise useful for fodder unless steeped in water to extract the alkaloids, which were liable to have toxic effects. Another drawback was the propensity of the ripe pods to split open, so that it was difficult to harvest the mature seed without heavy loss.

Economic stringency and the urge for self-sufficiency in certain European countries have recently led to some outstanding examples of the potentialities of applied science in regard to improving or supplanting natural products. One such example is the development of " sweet " or alkaloid-free lupins, which has been taking place independently in Germany and in Russia during the last few years. Dr. R. von Sengbusch is the scientist chiefly responsible for the development of " Süsslupinen " in Germany, and in a paper* published last year he outlines the history of their production, and the problems still to be solved.

The alkaloid-free strains were first obtained by the selection of a few individual mutants from vast populations (of the order of millions) of *Lupinus luteus* and *L. angustifolius*. To make this practicable, it was, of course, essential to devise a sufficiently rapid and reliable test for the desired character. Later, strains with non-splitting pods were isolated in the same way, and attempts are now being made to combine these two characters by breeding, in order to produce an alkaloid-free lupin which does not readily shed its seed, and can therefore be easily harvested as a grain crop. This having been done, further breeding work will be required to evolve strains adapted to the various climatic conditions under which lupins are grown, and to introduce other desirable characters such as softer seed-coats and higher oil content of seed.

The sweet lupin should be most valuable as a combined fodder and soil improvement crop on the infertile sandy soils common in North Germany.

* Aufgaben der Süsslupinenzüchtung (Problems of sweet lupin breeding). Forschungen u. Fortschritte, 13 : 232-234, 1937. By R. von Sengbusch.

It is hoped, however, that its usefulness will not stop at this. In pursuance of Germany's determination to extract the utmost from her internal agricultural resources, the aim is still further to improve the palatability of the sweet lupin, so that the seed may be used for human food. One of the greatest obstacles to self-sufficiency as regards food in Germany is protein shortage. It is stated that from 75 to 80 per cent. of plant protein is wasted in the process of conversion into meat ; hence the national importance of increasing the production of plant proteins edible by human beings. Since lupins will grow where other legumes will not, their special value for this purpose is obvious. The question of the extent to which plant proteins can safely replace animal proteins in human diet is passed over as being beyond the province of agricultural science.

Lupins also offer a means of increasing the supply of home-grown fats and oils. The seed normally contains 4 to 6 per cent. of oil, but in Russia, individual bitter lupin plants with seed containing up to 21 per cent. of oil have been discovered, again by the process of individual selection from very large populations. It is hoped by the Russian workers to combine high oil content with freedom from alkaloids by breeding. These instances of the modifications which may be brought about in a given crop by simple selection, provided it is on a vast enough scale, are of considerable practical interest. Von Sengbusch stresses the importance of maintaining stocks of seed of the older varieties, in order to provide material from which further selections may be made if required. A stock of at least 250 kgm. of seed of each lupin variety should be maintained for this purpose. It is suggested that potentially valuable breeding material is being lost through the disappearance of obsolete wheat varieties.

Possibilities in Australia.

Whilst it is to be hoped that the use of lupins as an article of human diet will continue to be of minor interest to Australians, it appears possible that the sweet lupin might be of some value here as a fodder crop. Over most of our continent, the limiting factor in land utilization is rainfall ; but where climatic conditions are most favourable soil conditions are all too often least favourable, as in the large tracts of infertile sandy country in parts of the coastal regions of the southern half of Australia. Many thousands of acres of bitter lupins, including *Lupinus hirsutus*, *L. pilosus*, and *L. varius*, are now more or less naturalised on sandy soils in Western Australia, where they are highly valued for the reduction of wind erosion, the addition of nitrogen and humus to the soil, and as summer and autumn sheep feed. Lupins are also grown on sandy ridges in parts of the Victorian and South Australian mallee wheat areas, where their main use is to reduce wind erosion. Sheep fatten readily on the seeds which are scattered from the pods when ripe, but they dislike the rest of the plants, though they may eat them when other food is scarce.

Some of the characteristics which are regarded as disadvantageous in other countries are actually desirable for this particular method of utilisation. For example, the non-palatability of the green plants enables the pasture to be grazed during winter, when other more palatable feed is available, without damage to the lupins, which it is desired to reserve for summer feed. Again, the delayed germination of a proportion of the seed is regarded as a fault under conditions of intensive culture in Europe, where crops of sweet lupins may be contaminated with bitter lupins from tardily germinated seed of a previous crop. Under Australian conditions, the natural regeneration of annual pasture plants is often a very desirable characteristic, and the delayed germination of a part of the seed may be essential to the permanency of the lupin crop on a given area. If the seed germinates too readily, summer rains may bring up a mass of seedlings which soon dry off, leaving no seed in the ground for germination at a more favourable time.

Nevertheless, it seems reasonable to expect that the greater palatability of the sweet lupin would render it more generally useful than the bitter lupin in Australia, provided that it grew and set seed as well as the older types. It should be suitable for use as green feed, hay, silage, or grain for all types of live stock, although it is not likely to displace clovers, lucerne, cereals, etc., on land capable of producing these crops. The improved German varieties of lupin can be exported only under an agreement with the importer to sell and reproduce the seed under licence. They are being grown under these terms in several European countries. The Council for Scientific and Industrial Research attempted to obtain a small quantity of seed for trial purposes, but the organisation handling the product made stipulations with which it was deemed impracticable for the Council to comply. This German organisation is now in communication with commercial agents here, and it is probably only a matter of time before sweet lupin seed will be available in Australia.*

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* The writer understands that sweet lupin seed is now on the market in Western Australia.

Factorial Treatments in Incomplete Randomized Blocks

By

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The method of balanced incomplete blocks described in [1], [2] and referred to in [3], section 17e was designed by Yates to meet the special requirements of observational data in which the nature of the material imposes a definite restriction on the number of units in naturally occurring groups, with a consequent restriction on the number of treatments which may be tested. Examples of situations in which this arrangement is of particular use are: litters of animals, paired material and in the local lesion method of testing the infectivity of virus preparations where there are usually not more than six suitable leaves on a plant. It is also of value in trials involving large numbers of varieties.[4]

This novel experimental arrangement is a modification of the familiar randomized block, analogous to confounding, which permits dispensation of the restriction that the number of units per block shall equal the number of treatments.

If t treatments are to be compared in b randomized blocks, each of k experimental units, $k<t$, block differences can be eliminated if it is arranged that every two treatments occur together in the same number, λ, of blocks. If there are r replicates of each treatment, the total number of experimental units is $tr=bk=N$, and $\lambda=r(k-1)/(t-1)$. With seven treatments a, b, c, d, e, f and g, in blocks of three, the following grouping of the treatments in seven blocks satisfies the conditions. In this case $\lambda=1$.

Block	1	*a*	*b*	*c*	Block	5	*b*	*e*	*g*
	2	*a*	*d*	*e*		6	*c*	*d*	*g*
	3	*a*	*f*	*g*		7	*c*	*e*	*f*
	4	*b*	*d*	*f*					

The treatment effects, free from block differences, are calculated from the t quantities

$$Q_i=kT_i-S, \qquad i=1, 2, \ldots, t$$

by dividing by krE. T_i is the total of all replicates of the ith treatment, S is the total of blocks containing the ith treatment and E is the efficiency factor of the incomplete block arrangement. It is equal to $(1-1/k)/(1-1/t)$ and measures the fractional loss of information when there is no reduction in the error variance per experimental unit when blocks of k, instead of blocks of t units, are used. Thus the effect of treatment i is

$$t_i = \frac{1}{krE} Q_i.$$

It should be noted that the quantity Q defined above is k times the analogous quantity defined in [2]. The adjusted mean of the ith treatment is

$$\frac{1}{krE} Q_i + \text{general mean.}$$

The sums of squares of treatments and blocks are as follow:

Treatments $\quad \frac{1}{k^2rE} \sum_{i=1}^{t} Q^2_i$

Blocks $\quad \frac{1}{k} \sum_{j=1}^{b} B_j^2.$

B_j is the total of experimental units in the jth block. The error sum of squares is obtained in the usual manner by subtraction from the total sum of squares. The estimated standard error of the difference between any two adjusted treatment means is the square root of $2s^2/rE$, where s^2 is the estimate of the error variance per experimental unit. Note that these expressions only differ from the standard formulæ used in ordinary randomized block analyses by the substitution of the Q's for the treatment totals and the introduction of the factors kE and k^2E.

In the literature cited above, no reference is made to the use of factorial systems of treatments in incomplete blocks. The purpose of this note is to point out that they may be employed, but at the same time it must be strongly emphasized that their indiscriminate use in this design is not being advocated. There are many eminently suitable designs for use in situations where it is desirable to resort to confounding, and the reader is referred particularly to [3] in which Yates has given a complete account of them. It is incumbent upon the experimenter first, to decide on the information he is desirous of obtaining, secondly, to devise a system of treatments appropriate to the questions being asked, and thirdly, to determine what experimental arrangement is best adapted to provide answers to his questions with the greatest possible precision, due consideration being given to the nature of the material with which he is dealing and the proposed system of treatments.

If the group of t treatments constitute a factorial system arranged in incomplete blocks, it may be readily shown that the only manner in which the functions representing main effects and interactions differ from the standard expressions of orthogonal data, lies in the substitution of the Q's for the treatment totals and the introduction of the factor kE. Similarly, the functions giving the contributions of the main effects and interactions to the treatment sum of squares differ from the standard expressions only in the use of the Q's and the addition of the factor k^2E.

As an example, consider the simple case in which four treatments, 2 factors a and b at 2 levels each, are arranged in four incomplete blocks of 3 units each;

$t=4$, $b=4$, $k=3$, $r=3$ and $E=\frac{8}{9}$. One arrangement of the treatments satisfying the incomplete block conditions is

a_0b_0	a_1b_0	a_0b_1	a_1b_1
a_1b_0	a_0b_1	a_1b_1	a_0b_0
a_0b_1	a_1b_1	a_0b_0	a_1b_0,

where the columns constitute the blocks. The table of Q's is

	b_0	b_1	
a_0	Q_{00}	Q_{01}	$Q_{00}+Q_{01}$
a_1	Q_{10}	Q_{11}	$Q_{10}+Q_{11}$
	$Q_{00}+Q_{10}$	$Q_{01}+Q_{11}$	0

The estimates of the main effects of the factors a and b are respectively,

$$\tfrac{1}{32}(Q_{11}+Q_{10}-Q_{01}-Q_{00}) \text{ and } \tfrac{1}{32}(Q_{11}+Q_{01}-Q_{10}-Q_{00})$$

and the estimate of their interaction is

$$\tfrac{1}{32}(Q_{11}+Q_{00}-Q_{01}-Q_{10}).$$

The divisor 32 is the product of two factors,

(i) $4r=12$, the factor which would ordinarily be used,

(ii) $kE=\frac{24}{9}$, depending on the incomplete block design.

The estimated standard error of each of the above quantities is the root of $\frac{1}{4rE}$ times the error variance per experimental unit.

The contributions of the three items to the treatment sum of squares are

$$\frac{1}{96}\{(Q_{11}+Q_{10}-Q_{01}-Q_{00})^2+(Q_{11}+Q_{01}-Q_{10}-Q_{00})^2+(Q_{11}+Q_{00}-Q_{01}-Q_{10})^2\}$$

$$=\frac{1}{24}(Q_{00}^2+Q_{10}^2+Q_{01}^2+Q_{11}^2) \text{ since } S(Q)=0.$$

As before, the divisor is the product of two factors, (i) $4r=12$, and (ii) $k^2E=\frac{72}{9}$.

TABLE I.

Values of Q.

Concentration of virus.

Medium.	1	1/2	1/4	1/8	1/16	1/32	1/64	*Total.*
Water ..	711	170	−335	−246	−247	−357	−883	−1187
0·05M. PO_4	963	385	731	315	−426	−417	−452	1099
0·10M. PO_4	591	599	−110	385	−426	−246	−705	88
Total ..	2265	1154	286	454	−1099	−1020	−2040	0

The following example, based on data given by Youden,[5] shows the numerical details involved in evaluating the contributions to the treatment sum of squares in the case of a 2-way classification of 21 treatments.

Table I summarizes the relevant information. In this example $b=21$, $r=5$, $k=5$ and $E=\frac{21}{25}$.

Treatment sum of squares:

$$\frac{1}{k^2rE}\sum_{i=1,j=1}^{3,7} Q^2_{ij}=\frac{1}{105}[711^2+963^2+\ldots+(-705)^2] \quad =52872\cdot2$$

Concentrations:

$$\frac{1}{3k^2rE}\sum_{j=1}^{7}\left(\sum_{i=1}^{3} Q_{ij}\right)^2=\frac{1}{3\times105}[2265^2+1154^2+\ldots+(-2040)^2] \quad =41776\cdot7$$

Media:

$$\frac{1}{7k^2rE}\sum_{i=1}^{3}\left(\sum_{j=1}^{7} Q_{ij}\right)^2=\frac{1}{7\times105}[(-1187)^2+1099^2+88^2] \quad = 3570\cdot8$$

Interaction:

$52872\cdot2-(41776\cdot7+3570\cdot8)$ $= 7524\cdot7.$

The complete analysis is:

Variation due to	Deg. freed.	Sum Sq.	Mean Sq.	S.D.
Plants (blocks)	20	34153·3	1707·7	
Leaf positions	4	6232·6	1558·2	
Concentrations	6	41776·7	6962·8	
Media	2	3570·8	1785·4	
Concen. × media	12	7524·7	627·1	
Error	60	23014·8	353·6	18·8
Total	104	116272·9		

TABLE II.

Adjusted lesion counts.

Concentration of virus.

Medium.	1	1/2	1/4	1/8	1/16	1/32	1/64	*Mean.*
Water ..	80·8	55·1	31·0	35·3	35·2	30·0	4·9	38·9
0·05M. PO_4	92·8	65·3	81·8	62·0	26·7	27·1	25·5	54·5
0·10M. PO_4	75·1	75·5	41·7	65·3	26·7	35·3	13·4	47·6
Mean ..	82·9	65·3	51·5	54·2	29·5	30·8	14·6	46·97

The reader's attention is drawn to the ingenious device, due to Youden (*loc. cit.*) for elminiating from the analysis, the variation caused by the ordinal position of the leaves on the plants. It is worth noting that this modification of the incomplete block design is of general application. A more recent discussion of the Youden square has been given by Fisher.[6]

The adjusted lesion counts are given in Table II.

The estimated standard error of the difference between

(i) any two adjusted concentration means is :

$$\sqrt{\frac{2}{3}\times\frac{5}{21}\times 353\cdot 6}=7\cdot 49 \text{ lesions},$$

(ii) any two adjusted media means is :

$$\sqrt{\frac{2}{7}\times\frac{5}{21}\times 353\cdot 6}=4\cdot 90 \text{ lesions},$$

(iii) any two adjusted means within the table is :

$$\sqrt{2\times\frac{5}{21}\times 353\cdot 6}=12\cdot 98 \text{ lesions}.$$

The procedure to be adopted with other factorial systems is obtainable as a mere extension of the above reasoning. With the aid of the following formulæ the variance of any comparison is easily evaluated. The variance of $Q_i = rk(k-1)\sigma^2$ and the covariance of Q_i and $Q_j = -\lambda k\sigma^2$, where σ^2 is the error variance per experimental unit of the hypothetical infinite population from which the sample was drawn.

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TECHNICAL NOTES

BREEDING EXPERIMENTS WITH QUEENSLAND FRUIT FLY (Strumeta tryoni Frogg.).

For some years, attempts have been made to breed the Queensland fruit fly in the laboratory, but hitherto this species has not been successfully reared in captivity. This is in striking contrast to the other, subordinate pest species—the Mediterranean fly—which will live for long periods and breed in cages without any special requirements as to food, moisture or type of cage. Further, the Mediterranean fly exhibits sexual activity during the day time and may often be observed in copula, whereas copulation of the Queensland fly has so far not been recorded.

Breeding cage used in fruit fly experiments.
(Photo by E. G. Pont.)

Six specimens of Queensland fly, including one male, were bred from second crop apples collected at Lindfield, N.S.W., emergence occurring on September 19th. These were placed in a small wooden cage, $5 \times 6 \times 7$ inches, having a sliding glass top and a fine wire gauze bottom. The cage was raised from the bench by means of corner supports approximately $\frac{3}{4}$ inch in height. The method of feeding was one recently published by Dean[1] and the food consisted of a smear on the glass composed of sucrose 2 parts, proteose protein 1 part, and water to moisten. A trace of yeast was added to this mixture as it is generally considered to be of value in the diet of most fruit flies.

Water was supplied by filling a wide-mouthed bottle and inverting over discs of blotting paper placed in a petri dish.

The food smear was replaced from time to time by sliding off the glass top, at the same time pushing the new glass into position.

Loquats were placed in the cage as this fruit is freely infested during October, but oviposition did not take place although the flies were often to be seen on the fruits.

A Granny Smith apple was next suspended in the cage, again without results. After a period of 24 days, an apple was punctured in several places with a fine needle to allow feeding on fruit juice to take place. This was immediately followed by egg deposition, and each puncture was repeatedly used for oviposition.

In view of the fact that the Granny Smith apples used were necessarily grown last season, it was considered that the skin had toughened to such an extent that natural " stinging " could not take place. Delicious and Yates apples were then used, and natural egg punctures were obtained although many unsuccessful attempts were observed.

Apples, similarly punctured, were placed with Mediterranean flies, and although eggs were taken from the punctures this species obviously is not attracted in the same way to the broken skin and is apparently more capable of piercing the skin of apples than is the Queensland fly, although Mediterranean flies are not considered a pest of pome fruits.

Although mating was not observed in the Queensland flies, the eggs were fertile, hatching in three days, and numbers of maggots have matured and pupated.

Egg deposition from a second batch of flies was secured in seven days using similar methods with the exception that yeast was not included in the food smear.

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Reference.

(1) Dean, R. W. Experiments on Rearing Apple Maggot Adults. Jour. Econ. Ent. 31 (2) 241-4, 1938.

SOIL FACTORS IN RELATION TO THE DISTRIBUTION OF SUB-TERRANEAN CLOVER AND SOME ALTERNATIVE LEGUMES.

The culture of mid-season subterranean clover has been a prominent feature of pasture improvement in southern Australia during the past fifteen years ; and it has become important to determine, first, the climatic and soil limitations to the growth of this species, and second, the extent to which alternative legumes may be employed.

In South Australia, it had become apparent by 1929 that the commercial mid-season (Mt. Barker) strain of subterranean clover was limited by conditions of moisture deficiency at or near the soil surface during the post-flowering period of the clover, and that these limiting conditions corresponded roughly with an annual rainfall of 25 inches in the central districts of South Australia and 19-20 inches in the south-east of the State. For this reason, the Mount Barker strain failed to form sufficient seed for adequate regeneration in each of the first five seasons in which it was sown at the Waite Institute (mean annual rainfall 1925-29=23·0 inches). Attention was therefore concentrated on the earlier maturing Dwalganup strain, which has given consistently good results over a period of nine years at this centre. It has now been found that the climatic delimitant to the growth of Mount Barker subterranean clover can be expressed as a 7·5 months effective winter rainfall period ; but several earlier strains such as Mulwala, Springhurst and Bacchus Marsh can be successfully grown where a shorter season occurs. These, moreover, have proved superior in yielding capacity to the Dwalganup strain under Waite Institute conditions.

In 1932, efforts were made to extend the use of the Dwalganup strain to areas of comparatively low rainfall, since observations at the Waite Institute had indicated that the rainfall season required for this strain was of but six months' duration, equivalent to an annual rainfall of 16 inches in South Australia. Concurrently, observations in the cereal districts of this State indicated that a second legume of possible value in areas of lower rainfall was barrel medic (*Medicago tribuloides*). This species had been gaining ground in the cereal districts at the expense of the common burr medic (*M. denticulata*), while it appeared to be superior to the latter in yield and persistence under grazing and was less objectionable in wool.

Investigations at lower rainfall centres were at first confined to two localities, namely Saddleworth (annual rainfall 20 inches ; rainfall season 7·2 months) and Gepp's Cross (annual rainfall 18 inches ; rainfall season 6·5 months). At each of these centres trials were conducted on light textured soils of granitic or quartzitic origin, and in each case the early maturing Dwalganup strain of subterranean clover was outstandingly successful. On the other hand, at Saddleworth, lucerne and *Medicago tribuloides* were failures. However, the subsequent practical extension of the use of Dwalganup subterranean clover to the cereal growing areas in general and to the mallee soils

and grey soils of the "Wimmera" type in particular gave disappointing results, whereas naturally occurring medics such as *M. tribuloides* and *M. denticulata* grew well on these soil types.

The key to a better understanding of the contrasting soil relationships of subterranean clover on the one hand, and of the *Medicago* species on the other, was provided by work in the south-east of the State. On two soil types of high lime status and alkaline reaction, one a calcareous sand* and the other a heavy black clay, subterranean clover failed to develop past the seedling stage, despite suitable climatic conditions. The high lime status and general alkalinity of these soils are also characteristic of the two other soils on which subterranean clover has failed, namely the grey soils and the mallee soils; and conversely, the podsolic soils and red-brown earths on which subterranean clover grows so well tend to be slightly acid or neutral in character, ranging from pH 5 to pH 7, and are characterized by a lower content of lime than the soils on which subterranean clover has failed. It appears evident that the failure of subterranean clover on the grey, mallee, heavy black and coastal calcareous soils is associated with high pH and high lime content of the soil.

The practical development that has followed this finding has been a swing towards the cultivation of the *Medicago* species on each of the soil types in South Australia to which subterranean clover appears to be unsuited. Lucerne, as a perennial legume within the group, is well adapted to these soils, while other valuable medics for commercial seeding are barrel medic (*M. tribuloides*) where the rainfall season is below 7·5 months, and black medic (*M. lupulina*) where climatic conditions are satisfactory for mid-season subterranean clover. As a result of the work, an area of barrel medic was harvested commercially for seed in 1937 and experimental seedings in 1938 with this seed have proved highly successful.

Interpretation of Field Observations.

Investigational work of a detailed character is necessary to explain the difference in ability of subterranean clover and of the medics to thrive on calcareous soils. While in a broad way it can be defined as a nutritional problem, the data do not indicate whether the factor involved is a deficient or unbalanced nutrition of the host plant or some influence on the rhizobial factor. The symptoms shown by subterranean clover on calcareous soils suggest a nutrient deficiency; and it appears that under conditions of high pH or high lime content of the soil this species is unable to utilize soil nutrients as effectively as the *Medicago* species. In this connection it is of interest that under pot culture conditions subterranean clover is much less efficient than the medics in utilizing phosphate supplied in the tricalcic form. Similar differences in the ability to utilize specific forms of other nutrients are likely to exist.

* D. S. Riceman and C. M. Donald, C.S.I.R. Pamph. 78, 1938.

Evidence is available that subterranean clover may be grown successfully on transitional soils bordering areas of highly calcareous soil.

Though no precise explanation is available, the recognition of the suitability of the *Medicago* species for use on calcareous alkaline soils, unsuited to subterranean clover, has an immediate practical application.

Difficulty has been experienced in establishing subterranean clover on ironstone soils of acid reaction (pH=5 to 6) in the Mount Lofty Ranges, and here the application of lime appears to be of promise. This result and the failure of subterranean clover on calcareous soils are not regarded as in any way anomalous. The quantity of lime required is insufficient to induce an alkaline reaction of the soil, and the complex of soil interactions involved is undoubtedly distinct from those associated with the failure on calcareous soils. Field investigations indicate a likelihood that subterranean clover may be established on these ironstone soils, while on calcareous soils the use of alternative species appears imperative.

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A METHOD FOR TESTING NITROGEN DEFICIENCY.

A simple test* for nitrogen deficiency in cereal crops has come under the notice of the author. It depends on the fact that nitrogen is absorbed from the soil in the form of nitrate and converted to other forms by the plant. When the plant has a poor supply of nitrogen the nitrate is converted as soon as it is absorbed, and nitrate cannot be detected by the chemical test described below. When the plant has an abundant supply of nitrogen the nitrate is not converted to other compounds as rapidly as it is absorbed by the plant. It can then be detected by the test.

The necessary reagent is made by dissolving 1 gramme of diphenylamine in 100 cubic centimetres of concentrated sulphuric acid, and the test is as follows :

Three plants, typical of the field or part of field to be examined, are selected. A thin disc is then cut from the main stem of each. These discs are placed on a strip of waxed paper or a glass or porcelain plate. Three drops of the nitrate reagent are added and the colour produced is noted. A dark blue colour indicates an abundant or excessive nitrogen supply ; a pale blue or greenish colour an adequate supply ; and no colour, accompanied by

* Thornton, S. F., Conner, S. D., and Fraser, R. R. : " The Use of Rapid Chemical Tests on Soils and Plants as Aids in Determining Fertilizer Needs." Perdue Univ. Ag. Exp. Stn. Circular 204 (Revised), 1936.

a pale green colour of foliage, a deficient supply. It is advisable to repeat the test several times from different parts of the field.

The materials used and the method of making the test are illustrated in the accompanying photographs (Figures 1 and 2). Figure 1 illustrates the cutting of discs from the stems of a cereal crop on to a porcelain plate with concave depressions for making spot tests. Figure 2 illustrates the addition of the nitrate reagent to the discs. In the foreground are three completed tests

Fig. 1.

Thin discs being cut from stems, in preparation for the nitrate test.

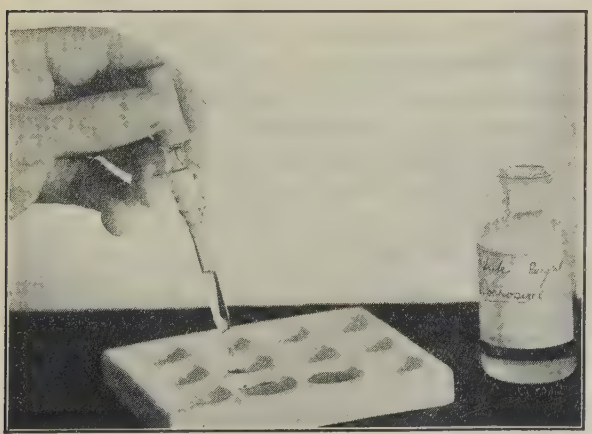

Fig. 2.

Nitrate reagent being added to the discs of plant material.

In the foreground are three completed tests which illustrate, from left to right, a deficient supply of nitrogen, an adequate supply, and an abundant supply.

which illustrate, from left to right, (1) a deficient supply of nitrogen, (2) an adequate supply, and (3) an abundant supply.

When made during bright weather the test has given a reliable indication of the nitrogen condition of plants on trials at the Waite Institute and at country centres. Under dull weather caused by heavy clouds, light becomes a limiting factor to the plant's activity. Nitrate may then accumulate in the

plant tissue, giving a blue colour when tested, even where the supply of nitrate in the soil is low.

As the test is simple, it could be applied to stubble crops in early spring, and those crops showing a deficiency could be top-dressed with a nitrogenous fertilizer. Trials at the Waite Institute have shown a spring dressing of sulphate of ammonia to be approximately as effective in increasing yield as a corresponding amount applied at seeding. Over a five-year period, the average increase from 1 cwt. of sulphate of ammonia was 15·67 bushels of barley per acre for a dressing applied at seeding, and 14·35 bushels per acre for a spring dressing. The corresponding increases for oats were 11·10 and 13·15 bushels per acre respectively.

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RESPONSE OF VICTORIAN PASTURES TO POTASH.

The splendid improvement effected in Victorian pastures in recent years has largely been brought about by the introduction of subterranean clover and the use of superphosphate. The results have been particularly good in southern Victoria where soil fertility rather than rainfall is the factor limiting growth, and despite the wide range of soil and pasture types in this area a good response to subterranean clover and superphosphate is almost invariably obtained. After the initial improvement, the responses to subsequent dressings of superphosphate are, however, not always so marked, partly because the direct responses to these later dressings are often masked by the residual and secondary responses of the earlier dressings. Generally it has been assumed that because superphosphate gave such spectacular results in the first years it would continue to meet the fertilizer requirements of the soil. More recently a good deal of evidence has been accumulating to suggest that, for the maintenance of improved pastures under southern Victorian conditions, the fertilizer requirement of the soil is by no means constant, and that the continued response to superphosphate depends on maintaining the available soil potash supply at a satisfactory level.

Mowing manurial pasture trials commenced in 1932 showed good responses to superphosphate and little response to potash during the first years. As these trials proceeded, potash assumed increasing importance, and on many of the areas the stage has now been reached where only small responses to superphosphate can be obtained unless potash is applied in addition. Weighed cuttings made in the early spring now frequently show increases to the order of 300 to 400 per cent. on plots receiving " super. and potash " as compared with those receiving superphosphate only. Individual plots all show this

trend, and the extent to which the general potash response has increased while the " super. only " response has declined on the Western District group of plots, is shown in Table A.

TABLE A.

Showing comparative annual yields from Western District (Victoria) group of plots, 1932-37. (Fertilizer at rates per acre.)

Year.	No Manure.	Superphosphate, 2 cwt.	Superphosphate, 2 cwt. +Potash, 1 cwt.
1932	100	140	154
1933	100	132	169
1934	100	148	151
1935	100	116	195
1936	100	125	223
1937	100	115	181

These results have been obtained under a system of repeated mowing and removal of the clippings from the experimental area, but similar potash responses—though to a less marked degree—have been observed on adjoining grazing trials.

New trials established within the then suspected potash deficient areas in 1935 showed a potash response from their inception and, as is indicated by the figures in Table B, the relative yields are now showing an increasing response to " super. and potash " and a diminishing response to either superphosphate alone or superphosphate plus lime.

TABLE B.

Showing comparative annual yields (grouped) from plots in potash responsive areas of Western District (Victoria). (Fertilizer at rates per acre.)

Year.	No Manure.	Superphosphate, 2 cwt.	Superphosphate, 2 cwt., Lime, 1 ton.	Superphosphate, 2 cwt. +Potash, 1 cwt.
1935	100	138	153	166
1936	100	160	159	221
1937	100	131	139	181

Recently some good responses to potash have been recorded on individual plots in Gippsland, and numerous instances of pasture deterioration—apparently resulting from soil potash exhaustion—have been observed on improved

pastures on dairy farms in southern Victoria. Usually in these cases, too frequent grass-hay cutting or the failure to return plant growth to the pasture as animal excrement has brought about, though more slowly, a soil potash deficiency similar to that which has been developed on the experimental plots.

A marked diminution and, in severe cases, an almost complete absence of clovers, despite liberal applications of phosphates, is the usual feature of the swards on the potash deficient soils. Yorkshire fog grass, rib-grass and flat weed (*Hypochæris*) together with sweet vernal, stunted perennial rye and moss usually form the bulk of the sward on such areas.

The responsive soils, generally podsols, do not possess any special, common characteristics, and the potash deficiency appears to be connected more intimately with the previous management of the land and pasture rather than with the structure or origin of the soil. As might be expected, the lighter poorer soils have shown potash deficiency symptoms much more quickly than the heavier, clay loams.

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A BACTERIAL DISEASE OF STOCKS.

During the past year a bacterial disease of stocks (*Matthiola incana* R. Br. var. *annua* Voss), apparently hitherto unreported in this country, was observed in several localities in the Sydney Metropolitan Area and at Wyong, where it was responsible for heavy losses in some plantings. It is proposed in this paper to outline the studies so far made by the writer on this subject, and to summarise the work of other investigators on similar diseases of the same host.

Historical.

Bacterial diseases of stocks have been described by several workers. Von Faber,[9] in 1907, recorded the crucifer black rot organism [*Bacterium campestre* (Pammel.) E. F. Smith] as causing a disease in stocks in Germany. In 1912, Briosi and Pavarino[2] described a bacterial disease of stocks in Italy, naming the causal organism *Bacterium matthiolæ*. Rudorf and Job,[7] in 1932, reported the occurrence of a bacterial disease of stocks in Argentine and decided that the organism responsible was *Bact. matthiolæ*. Cooley,[4] in 1932, described a bacterial disease of the same plant in Tennessee and concluded that the causal organism was *Bact. campestre*. In 1934, Adam and Pugsley[1] recorded a bacterial disease of this host in Victoria but did not name the causal organism, although they concluded that it was distinct from both *Bact. campestre* and *Bact. matthiolæ*. More recently, Kendrick[6] has described a bacterial disease of stocks in California. Kendrick states that the pathogen resembles *Bact.*

campestre in morphological and cultural characters but that reciprocal cross inoculations failed to result in infection.

Symptoms.

Affected plants collected in various sections of the Sydney metropolitan area were noticeably stunted, the lower leaves turning yellow and falling off. In cases of severe infection the plants wilted and were often completely killed. Black, slightly sunken, somewhat water-soaked lesions developed at the points

Portion of affected stock plant.

Arrows point to the black, sunken lesions where subsidiary stems joined the main stem.

(Photo by E. G. Pont.)

of attachment of the leaves to the stems and of the subsidiary stems to the main stem. Internally, the vascular tissue was blackened but this blackening was not confined to the vascular area as the discolouration extended also to adjacent tissues.

The Causal Organism.

Microscopic examination of diseased plants showed masses of bacteria associated with affected portions of the stem. On dilution plates of beef extract peptone agar, the resulting colonies were predominantly yellow in colour. Stock seedlings, inoculated by puncturing the stems with a needle dipped in agar slope cultures derived from these yellow colonies developed

symptoms similar to those seen on affected plants collected in the field. An organism possessing characteristics identical with those of the original isolation was reisolated from inoculated plants.

Morphological, cultural, biochemical and physiological studies showed that the organism is a Gram-negative, non-spore-forming, aerobic rod, motile by one polar flagellum and varies from 1·5 to 3·0 μ by 0·6 to 0·9 μ in size. An abundant yellow growth is produced on beef extract peptone agar and on potato dextrose agar. The organism hydrolyses starch, liquefies gelatin, does not produce indole from tryptophane broth, and does not reduce nitrates to nitrites.

In determining the action of the organism on various carbohydrates, the basal medium employed was the modification of that of Ayers Rupp and Johnson as given in the *Manual of Methods for the Pure Culture Study of Bacteria*. One per cent. of the carbohydrate being tested and 1·5 per cent. of agar were added to this medium. It was found that the organism grew very much better on a solid medium than in a liquid medium, no matter what carbohydrate was used. This may, perhaps, have been due to the presence in the agar of minute quantities of materials essential for growth. Using this solid medium, growth occurred with the production of acid when dextrose, sucrose, galactose, raffinose, lævulose, xylose, arabinose, mannose, mannitol, glycerol and maltose were employed as the sources of carbon. The rate of growth and acid production varied considerably with various media used, and in the case of maltose the rate of acid production was particularly slow. Very slow growth, but no acid production, occurred when lactose and salicin were used and no growth was obtained with rhamnose.

Cabbage, cauliflower, swede turnip, radish and wallflower seedlings were inoculated by puncturing the stems with a needle dipped in an agar slope culture of the organism, but no definite infection was secured in any case.

Conclusions.

The cultural and physiological characteristics of the causal organism are in reasonably good agreement with those given by Elliott[5] and Smith[8] for *Bacterium campestre* (Pammel) E. F. Smith. The carbohydrate fermentation results, in particular, are in good agreement with those recorded by Burkholder[3] for the same organism. However, the failure of the organism to infect other cruciferous plants indicates that it is not identical with *Bact. campestre*. The nature of the symptoms as well as characteristics of the pathogen in culture indicate that the disease is quite distinct from that caused by *Bact. matthiolæ* and from the disease reported by Adam and Pugsley.[1] It is possible, however, that the disease recently discovered in New South Wales may be the same as that reported by Von Faber,[9] Cooley,[4] and Kendrick.[6] Kendrick appears to be the only one of these workers who has

tested the pathogenicity of the causal organism on crucifers other than stocks. It is of interest to note that Smith[8] failed to secure infection of stock plants inoculated with *Bact. campestre* isolated from cabbage and cauliflower.

It is concluded that the disease occurring in New South Wales is probably the same as that recorded by Kendrick[6] in California and that the causal organism is closely related to *Bacterium campestre* (Pammel) E. F. Smith.

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MEASUREMENT OF BEETLE BORER MIGRATION IN BANANA PLANTATIONS.

Without touching on the vexed question of flight (which has never been directly proved to occur in Australia) there are two questions in regard to the migration of *Cosmopolites sordidus* which are of practical importance. These are :

Firstly, do the beetles in their normal everyday mode of progress move freely about between the stools of a plantation ; or is migration rare and limited in scope ?

Secondly, if such a migration exists, can it be checked by maintaining a strip of weeds* or grassland between infested and uninfested plantings ?

Froggatt[1] records that " a new plantation alongside an old infested area, though free from beetle borer early in the year, was found infested in the spring in the two rows adjoining the old area ". Although this record strongly suggests an infiltration of beetles from the old into the new planting, there is nothing in the account to rule out the possibility that some of the new suckers contained eggs or larvæ of the beetle before they were planted. Moreover, as the distance

* This expedient appears to have been first suggested by Ridley in Jamaica, 1916. (See Rev. Appl. Entomology, Vol. 4, p. 255.)

between the old and new plants is not stated, it is hard to deduce the actual distance travelled by any invading beetles.

As no other data on these questions could be found in the literature, the writer decided to carry out measurements of the actual range of movement shown by individual beetles.

Experiment A.

In January, 1934, this preliminary test was conducted in an old, heavily infested plantation near Lismore. A total of 64 beetles lightly marked with a stripe of lead paint in four different ways was placed in 16 different stools. The same day, baits were laid in 5 other stools enclosed by the 16, while 6 other baits were laid in positions close to the 21 stools under discussion. Three days later, baits were laid in the 16 stools in which beetles had been placed. From several examinations of the baits, a total of 21 out of the 64 marked beetles was recovered by the 8th day. However, only one of these 21 beetles was found in a stool where beetles of that pattern had not been placed. The minimum distance it could have travelled was $8\frac{1}{2}$ feet.

This result pointed to a low frequency and range of migration although it was realised that results might have been different if more of the surrounding stools had been baited. Again, migration must have been lessened by the presence of baits (for 5 days out of 8) in the stools where beetles had been placed. In any case, a new experiment was called for when two weeks later one of the marked beetles was found at a bait at least 70 feet away from its point of liberation.

Experiment B.

This was carried out in the same plantation but was separated by a space of 70 yards from the stools of Experiment A. Four sets of beetles were marked with a white dental cement (zinc oxychloride) applied to different parts of the body so as to give markings contrasting with each other and with the patterns in Experiment A.

On 6th March, 1934, a total of 173 marked beetles was placed out in 14 stools forming three sides of a rectangle (see Fig. 1). The intention was to leave them for a fortnight and then to ascertain their position by laying baits throughout that zone of the plantation.

On the following day, however (7th March), the writer, in the course of other work, had occasion to examine certain poison baits in stools adjoining those where beetles had been liberated the day before. Among the beetles at the poison baits he was surprised to find 4 of the marked beetles liberated in other stools 24 hours earlier. Two of these had come not less than $8\frac{1}{2}$ feet; one had come at least $12\frac{1}{2}$ feet, while the other had travelled at least 20 feet from its stool of origin.

A fortnight later (22nd March), unpoisoned baits were laid in about 70 stools surrounding and including the 14 stools where beetles had been liberated, the aim being to determine the spread of beetles during the $2\frac{1}{2}$ weeks following their liberation. On 23rd March, these baits yielded a total of 17 marked beetles, two of which had moved at least 38 feet and 36 feet, respectively, from their points of origin. Six other beetles had travelled distances varying from $18\frac{1}{2}$ to 25 feet from their nearest possible stools of origin. Only 4 of the 17 beetles recovered were found in stools where beetles of that particular marking had been liberated $2\frac{1}{2}$ weeks earlier. (These four are indicated in Fig. 1 by circular dots placed above the stools in which they were found.)

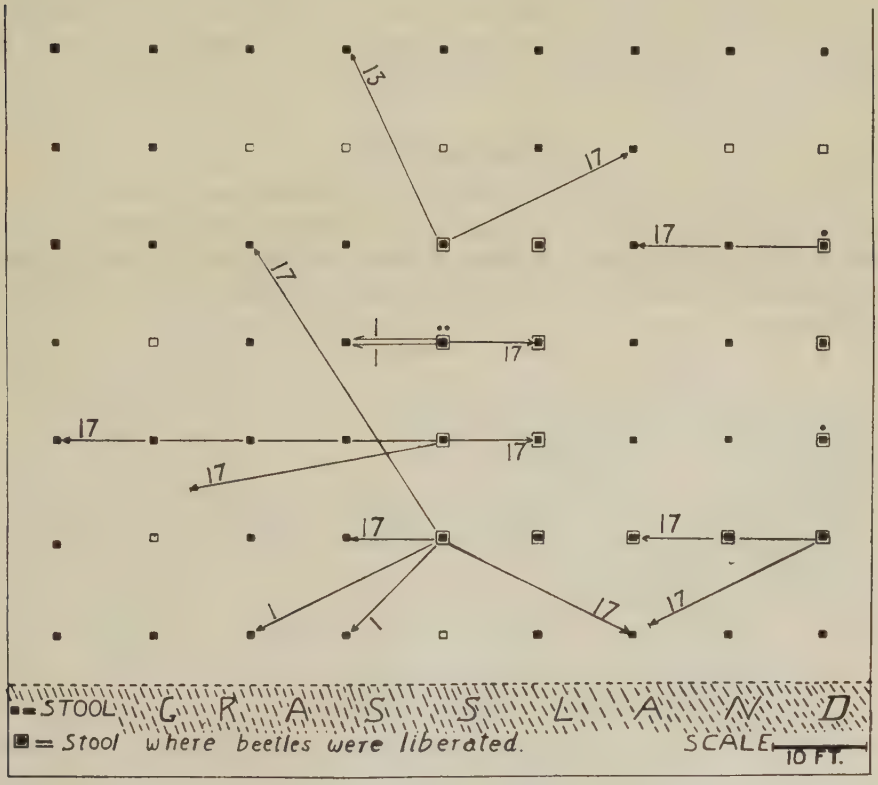

Fig. 1.—*Migration of marked beetles.*

In Fig. 1, the lines terminated by an arrow-head were obtained by joining the place where a marked beetle was found to the nearest stool in which it could have originated. Each line has a number upon it denoting the number of days between the date of liberation and the date of finding the beetle. The stools are indicated by black squares, while the few empty white squares signify open ground formerly occupied by stools which were lost through bunchy

top. The centres of the stools are 10 feet apart, but many of the stools were $2\frac{1}{2}$ to 3 feet in diameter ; therefore, the distance from the outside plants in one stool to a bait placed in the centre of another stool would be $8\frac{1}{2}$ feet.

Conclusion.—This experiment indicates a fair range and frequency of migration between stools in plantation order. It is, of course, possible that if more stools had been baited a range of more than 38 feet might have been shown. It is interesting to note that the weevil can travel 20 feet overnight within a group of stools, for the beetles' movements are somewhat sluggish and do not suggest mobility.

It was important to secure information on the spread of the beetles from one plantation to another when their continuity was broken by a strip of grassland. It happened that such information was available in the course of another series of investigations at Dunoon.

Experiment C.

In December, 1933, a quarter-acre block of land was selected from a grazing paddock between two old infested plantations near Dunoon. The land was ploughed, leaving a strip of grassland of varying width to separate the quarter-acre block, B, from the infested plantations, A and C, nearby (see Fig. 2).

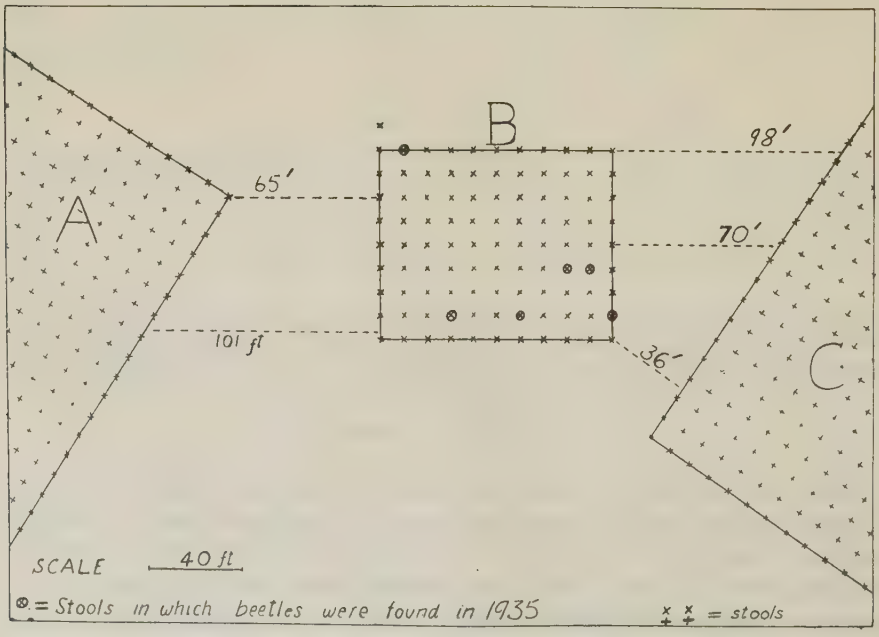

Fig. 2.—*Relative positions of plantations, Dunoon.*

The land was planted by the writer with 100 suckers from a plantation in the forest south of Broadwater, a district where *C. sordidus* had not been recorded before or since, and 15 to 20 miles from the nearest infestations. The suckers were therefore beyond any suspicion of infestation. They were taken directly from the road to the ploughed land and planted without delay.

The suckers grew vigorously, and by the end of 1934 had all produced strong healthy stools. As a matter of interest, baits were placed out in all stools during April, 1935, and again in the first week of May. These baits were carefully selected and free of beetles, larvæ or pupæ. *Results*: the two long-term baitings yielded a total of only seven beetles from the 100 stools, distributed as shown in Fig. 2.

The trifling nature of this infestation is clear when it is considered that a block of stools in the adjacent plantation, A, yielded 113 beetles from only 64 stools baited only once. One stool of the 64 yielded more beetles from its one baiting than were found in the whole 100 stools of the quarter-acre in two baitings. This baiting of plantation A was carried out within a few days of the April baiting of the 100-stool plot, B.

Conclusion.—Beetles were found to have migrated across a belt of *Paspalum dilatatum* whose width varied from 12 yards to 34 yards. However, considering the fact that the clean, new plantation had been growing for 16 months so close to the heavily infested old plantations, the degree of infiltration seems very small.

Comment.—This 100-stool plantation later came into bearing with vigorous and healthy growth of the plants. This record is important from the viewpoint of practical banana growing, for it was demonstrated that beetle-free suckers well cultivated and buffered by a zone of grassland turf, were planted with impunity close to a heavily infested plantation.

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EFFECT OF CULTIVATION ON SUSCEPTIBILITY OF BANANAS TO BEETLE BORER.

The chief operations involved in proper cultivation of bananas are maintenance of tilth and destruction of weed growth, pruning (desuckering), deleafing, and attention to soil fertility, which may include manuring where necessary. The terms " cultivation " and " cultural methods " are sometimes used in the literature on banana borer to include the destruction of spent banana material and general debris which may breed pests. This usage will not be followed in this paper.

In 1916, Cousins,[1] in Jamaica, was quoted as holding the view that good cultivation presents marked obstruction to *Cosmopolites sordidus*. In the following year, Watts[2] undertook a field survey of the borer in Jamaica, which included dissection of plants in many stools. He concluded that deep and severe tunnelling by *C. sordidus* was correlated with lack of vigorous growth in the plants, due possibly to a number of causes, including lack of cultivation and the presence of fungous disease. Watts strongly advocated that a field experiment be set out to test the effect of good cultivation on the plants' resistance to beetle borer.

In the twenty years following Watts' account, a number of workers, observing the general correlation between good cultivation and freedom from border damage, advised cultural methods as a control measure. For example, McCarthy,[3] in Australia, stated: " Observations tend to show that plants lacking in vitality are more readily attacked." He stressed the need for good cultural methods (including desuckering), and expressed the view that where these are employed, damage by beetle borer can be kept down to an almost negligible quantity.

Despite the numerous references to this subject in the literature, the writer could find no reference to any experiment carried out to illustrate the effect of cultivation on resistance to or escape from attack by *C. sordidus*. Accordingly, it was decided to investigate this correlation by the following experiment at Leycester, near Lismore.

Aim of Experiment.

The aim of this trial was to grow two sets of beetle-free plants adjacent to each other but differing widely in their vigour of growth, this difference in vigour to be induced by subjecting the plants to different cultivation programmes. When the plants had struck root and established themselves, they were to be subjected to a population of beetles and the ensuing amounts of damage noted.

Site.

During the autumn of 1934, about an acre of old heavily infested banana plantation had been dug out and planted to French beans, which occupied the

ground during the winter months. By late September, the land had reverted to a light growth of weeds. The ground, of course, was clear of banana stools, but at intervals of a chain and upwards were stacks of undestroyed banana material—pseudostems and rhizomes—carrying an appreciable infestation of beetle borer. This debris had been dragged into compact heaps by the grower so as to clear the soil for bean cultivation. A small plot of land about 12 by 7 feet was selected as being of apparently uniform soil conditions and fairly distant from the nearest heap of debris.

Preparation of Plot.

The plot was prepared as shown in Fig. 1. On 21st September, 15 holes were dug in the positions A1 to B7, the centres of the holes being 22 inches apart. The holes dug for suckers of the " A " series were of the usual type made in planting bananas, being about 12 inches square. The holes of the " B " series, however, were circular in section and slightly shallower ; they were also much narrower, being only about 6 inches in diameter. All 15 holes

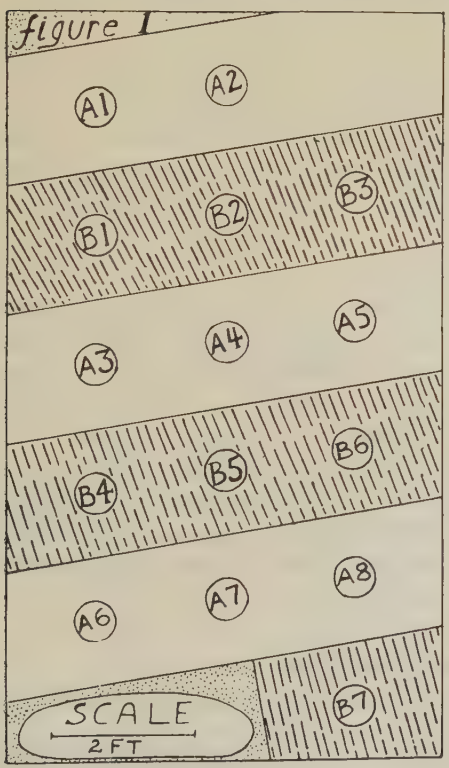

Fig. 1.—*Layout of plots.*

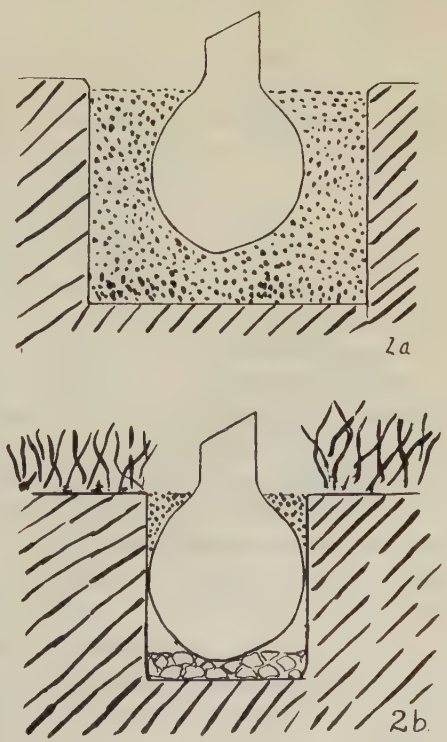

Fig. 2.—*Manner of planting suckers.*
2a—*Suckers of Series A.*
2b—*Suckers of Series B.*

and the weeds growing around them were left undisturbed for the ensuing four weeks.

Planting.

At the end of this period (i.e. on 16th October, 1934), 15 large uniform suckers were planted in the holes prepared. These plants were beetle-free, having come from the Broadwater plantation mentioned previously.[4] The suckers were taken straight from the road and planted without delay.

Suckers in the " A " series of holes were planted in the usual way, i.e. the sucker was placed upon a few inches of loose soil thrown into the bottom of the hole, which was then filled with the remainder of the soil which had been removed (see Fig. 2a).

Suckers in the " B " series, however, rested only on a thin layer of coarse soil stirred from the bottom of the hole. Moreover, owing to the narrowness of the holes the lower part of each " B " sucker was in contact not with soil of fine tilth but with the actual wall of the hole. The upper part of each sucker, however, was buried in fine surface soil, as shown in Fig. 2*b*.

Within two days (18th October) the soil round the " A " series suckers was chipped with a hoe to destroy weeds, with the result that each row of " A " suckers was growing in a strip of tilled soil 22 inches wide (see Fig. 1). Round the " B " series suckers, however, the weeds were left untouched so that each row of suckers was growing in a strip of weedy ground 22 inches wide.

Precautions.

It was explained that infestation of the plants was to be delayed at least till they had established themselves. To this end, the plot had been placed as far as possible from any stacks of debris. Moreover, to localise infestation within the debris baits were placed under and beside the stacks ; these were regularly examined and renewed and all beetles caught were killed. As a further check, additional baits were placed at intervals around the plot to intercept any migrating weevils. These baits were also regularly examined, and the few beetles found were killed. This baiting programme was started about a month before planting the suckers, and was continued long after the planting (at least till the beginning of November).

Course of the Experiment.

The suckers were planted on 16th October, 1934, and the " A " series strips were chipped on the 18th. Rain fell on the 18th and 19th November, and all suckers established themselves, for by 31st December all plants had made appreciable growth. By that date a fairly heavy growth of weeds had appeared in the uncultivated strips, and the " A " series plants had far outstripped the

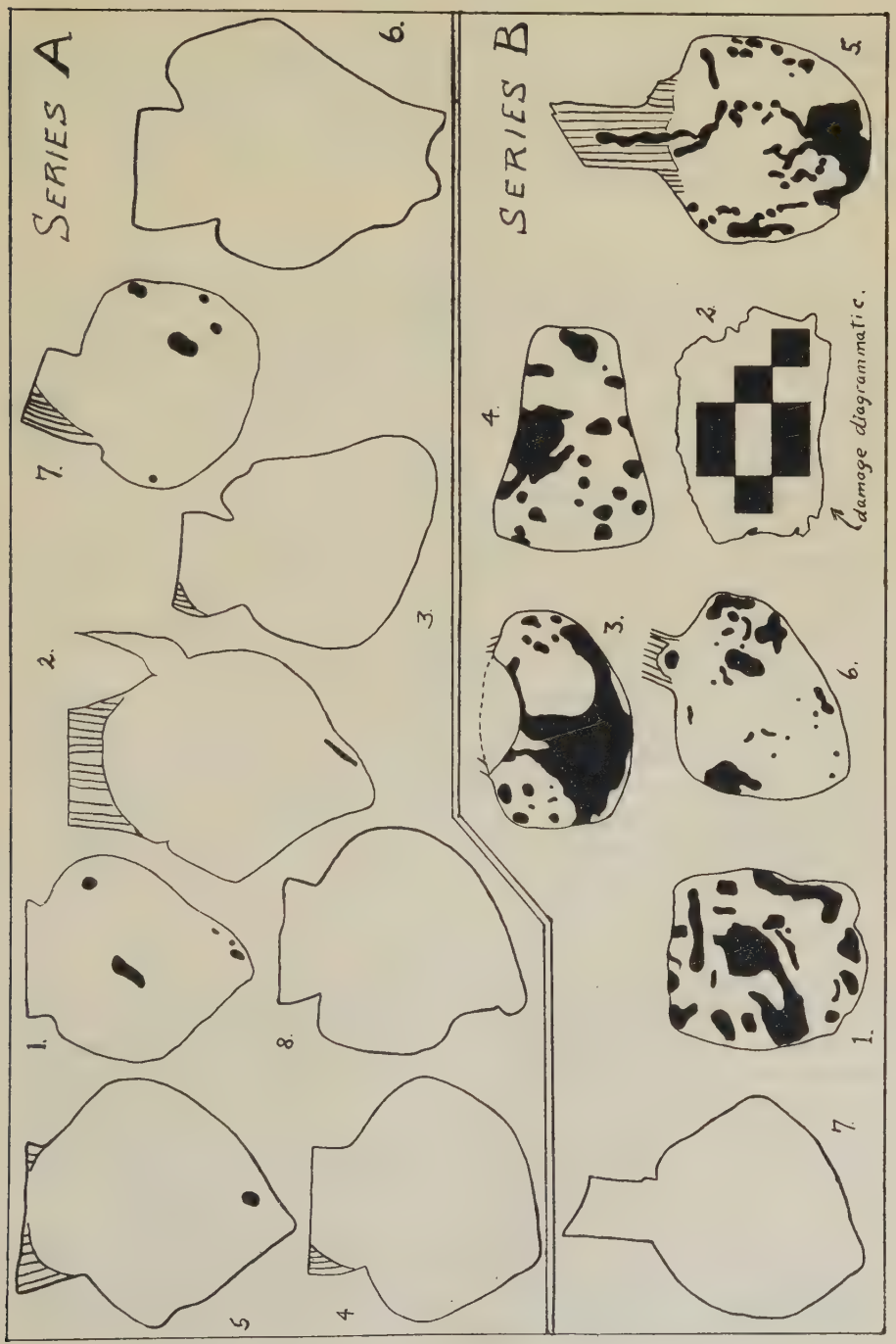

Fig. 3.—*Median sections through banana suckers.*

others in growth. The " A " series plants were chipped that day (31st December), after which the writer did not see the experiment for three months. However, on 31st January, 1935, a chipping was carried out in the required plants by an assistant, after which the experiment remained untouched till 8th April. No artificial infestation of the plot was carried out, but a natural infestation occurred, as shown below :

Result.

(*a*) *Inspection.*—By 8th April a heavy mat of weeds had developed in the neglected strips, while a light weed growth was present in the cultivated strips. Plants B1, B2, B3 had died, and careful search was required to detect the remnants. In B4 the leaves were dying or dead, while in B5 and B6 the centre leaf was dead, and three or four other leaves were dying on each plant. B6 and B4 had stems of 1½ inches in diameter at ground level, showing four and five full-sized grub tunnels at the base of the stem. B7 was a healthy plant with a well-developed stem and no dead leaves.

In all the " A " series suckers, all leaves were healthy and the stems well developed ; A2 was actually suckering. It was noticed that the weed growth around B7 was less dense than in the other " B " strips, and it was thought possible that the assistant in his work of 31st January had inadvertently cultivated this plant along with the adjacent suckers A6, A7, A8.

(*b*) *Dissection.*—All plants were dug out and dissected as follows : A median longitudinal cut was made through the rhizome and base of the stem. A second cut was then made through the rhizome at right angles to the first. All tunnelling exposed was carefully drawn in diagrams. The diagram of the first longitudinal cut through each of the 15 suckers is reproduced in Fig. 3 at approximately one-fifth actual size. The solid black marks indicate the larval tunnels exposed by the cut.*

Conclusion.

Two groups of similar beetle-free suckers, grown close together and interplanted, were subjected for 6 months to 2 widely different sets of cultural conditions. The variable factors were : (*a*) Initial growing conditions (influenced by manner of planting), (*b*) amount of weed growth present, and (*c*) state of soil tilth. The suckers almost certainly began their growth unattacked by *C. sordidus*, but at a later stage migrating weevils reached the plot and oviposited freely. The experiment showed a very marked difference in the amount of larval damage sustained by the 2 groups of plants. It

* In the dissection of B2, there was no time for a careful reproduction of the tunnelling which was extremely elaborate, but a note was made at the time that the degree of damage was greater than in B1. In preparing Fig. 3, the percentage area of B1's damage was therefore measured, increased by 1 per cent., and the resulting percentage of B2's area blocked out on the outline of that sucker.

indicates (i) that favourable planting conditions followed by moderately good cultivation induce a high degree of resistance to or escape from attack by *C. sordidus*, and (ii) that the presence of bad growing conditions and poor cultivation render banana plants extremely susceptible to attack by *C. sordidus*.

C. R. WALLACE.

Entomology Branch,
Department of Agriculture,
Sydney.

References.

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(2) Watts, F. Journ. Jamaica Agric. Soc. XXI : 6, p. 170, 1917.
(3) McCarthy, T. Agric. Gazette N.S.W. XXXI : p. 871, 1920.
(4) Wallace, C. R. Jour. Aust. Inst. Agric. Sci., 4 : p. 215, 1938.

The Australian Institute of Agricultural Science

SECOND GENERAL MEETING—AT CANBERRA.

DETAILS OF TENTATIVE PROGRAMME.

9th January—
9.30 a.m. .. Council Meeting.
2.00 p.m. .. Second General Meeting—Business Session.
8.00 p.m. .. Presidential Address.

10th January—
9.30 a.m. } Discussion of Institute projects.
2.00 p.m. }

Proposed agenda for the Council Meeting :

1. Minutes.
2. Business *ex* minutes.
3. Consideration of report of Council and financial statement for presentation to general meeting.
4. Journal reports—Editor and Business Manager.
5. Election of President for 1939.
6. Other Business.

Proposed agenda for the Business Session of the General Meeting :

1. Minutes.
2. Report of Council and Financial Statement.
3. Notified business.
4. Progress reports and discussion on Salary and Status survey.
5. Date of next meeting.
6. Other Business.

It is suggested that, as at the previous meeting in Sydney, dinner dress should be worn by those attending the Presidential Address.

The projects suggested for discussion on the following day are :

1. Progress reports and discussion on the potentialities and population survey of the Commonwealth. The various Branches have been requested to furnish short reports on the progress made on the surveys in their own States.
2. Plant Quarantine, a report on which has already been circulated by the A.C.T. Branch, while an article by the President of the Tasmanian Branch was published in the September issue of the Journal.

The installation of the incoming President will take place at the conclusion of the afternoon session on 10th January.

The President and members of the A.C.T. Branch wish to entertain visiting members at supper on the evening of 9th January after the Presidential address.

An official Institute Dinner will be held at the Hotel Civic, Canberra (charge, 4/6 per head), on the evening of 13th January.

MEETINGS OF COUNCIL.

SEPTEMBER MEETING.

Held in School of Agriculture, Melbourne University, on 13th September, at 8 p.m. *Present*: The President, Professor S. M. Wadham, in the chair; Messrs. Brake (V.), Miller (Q.), Davis (N.S.W.), Dr. Forster (W.A.), the Honorary Secretary, Mr. Vasey, the Honorary Treasurer, Mr. Twentyman, and Mr. J. L. Gillespie by invitation.

Apologies were received from Dr. Richardson (S.A.) and Messrs. Geddes (T.) and Leeper (A.C.T.).

The Hon. Secretary reported that the Business Manager of the Journal had submitted his views on the question of Journal exchanges and the review of the present free distribution lists, for which purpose he had submitted copies of these lists. The Council expressed appreciation of the careful consideration which Dr. N. S. Noble had given to this matter, and appointed a sub-committee, consisting of the President, Dr. Forster (W.A.) and the Hon. Secretary, to examine Dr. Noble's recommendations and report to the next meeting of the Council.

All Branches now having had the opportunity of considering the President's memorandum on salary and status, unanimous appreciation was expressed of this document and support for the proposed survey. On the recommendation of the N.S.W. and S.A. Branches, it was decided to circulate the memorandum to individual members, and to supply tabulated statements on which the returns from their enquiries might be made.

As a result of comments from Branches, it was decided to adopt the suggested practice of preparing specially printed slips to facilitate collection of subscriptions by Branch treasurers.

The following applicants were admitted to membership: Hayman, R. H. (Vic.), Hicks, F. W. (Tas.), Hogan, T. W. (Vic.), Littlejohn, E. B. (Vic.), Nicolls, K. D. (Vic.), Rees, H. V. (Tas.), Waite, A. N. (Vic.), Goldstone, C. R. (Tas.).

The resignation of Dr. J. G. Churchward, under date 15th August, as a member of the Institute was accepted.

The financial statement showed cash at bank on 13th September to be £145 17s. 5d.

As further receipts in the near future should be sufficient to meet all anticipated expenditure to 31st December, 1938, the Hon. Treasurer moved that a further £100 should be placed on fixed deposit for two years at 3 per cent. This was seconded by Mr. Davis (N.S.W.) and carried unanimously.

OCTOBER MEETING.

Held at the School of Agriculture, Melbourne University, on 6th October, at 8 p.m. *Present ;* The President, Professor S. M. Wadham, in the chair ; Messrs. Miller (Q.), Geddes (T.), Leeper (A.C.T.), Gillespie (N.S.W.), Dr. Forster (W.A.), the Honorary Treasurer, Mr. Twentyman, and the Honorary Secretary, Mr. Vasey. An apology was received from Mr. Brake (V.) and permission was given to Mr. Miller (Q.) to act on his behalf.

The sub-committee appointed at the last meeting presented its report on the Business Manager's recommendations in connection with the circulation of free copies of the Journal. It recommended the acceptance of Dr. Noble's suggestions that in future free copies of the Journal be sent only to public libraries in Australia and abroad (one in each foreign country), selected abstracting journals, and kindred associations.

The Hon. Secretary reported that registration and incorporation of the Institute had now been completed.

The following applicants were admitted to corporate membership : Cariss, H. G. (W.A.), Edmonds, A. G. (Vic.), Gayford, G. W. (Vic.), Itzerott, A. G. F. (Vic.), McKeon, B. F. (Vic.), Miller, L. W. (Vic.).

The financial statement showed cash at bank on 5th October to be £49 7s. 5d.

NOVEMBER MEETING.

Held at the School of Agriculture, Melbourne University, on 3rd November, at 8 p.m. *Present ;* The President, Professor S. M. Wadham, in the chair ; Messrs. Brake (V.), Geddes (T.), Gillespie (N.S.W.), Leeper (A.C.T.), Dr. Forster (W.A.), and the Honorary Secretary, Mr. Vasey.

Apologies for absence were received from Dr. Richardson (S.A.), Mr. Miller (Q.) and the Hon. Treasurer, Mr. Twentyman.

Opinions on the application of Article 29 received to date indicate the feeling among delegates that a Branch is quite at liberty to express its views on any local matter provided such are distinctly stated to be the views of the Branch only and not of the Institute as a whole. As opinions on this question had not yet been received from all delegates, it was decided that should further discussion be requested by any delegate it should take place at the Council meeting on 9th January, provided notification of same was received before next meeting.

Mr. N. H. White (A.C.T.) was admitted to corporate membership.

A letter was received from the Business Manager of the Journal seeking a direction from the Council on the functions of the Publications Committee in relation to the business management of the Journal.

After discussion, the Council decided that while this committee was originally appointed to assist with the arrangements connected with the enlargement, etc., of the Journal, early in 1937, it desired that it continue to function for the general assistance of the Editor and Business Manager.

The financial statement showed cash at bank on 2nd November to be £50 5s. 2d.

The following resolution in connection with the discussion on Plant Quarantine, which is to take place at the general meeting of the Institute at Canberra, was received from the Tasmanian Branch :

> " Whilst agreeing in principle with the Memorandum on Plant Quarantine circulated by the A.C.T. Branch, it was considered that any Plant Quarantine Board appointed should also be concerned with interstate Quarantine Regulations. Also that there would be more likelihood of a reorganisation of the quarantine staff taking place if a less costly scheme were proposed."

The President announced that as he would be leaving for abroad on 24th December, he regretted he would be unable to preside at either the Council or general meeting in

Canberra. The application in the circumstances of Articles 34 and 55 (*a*) was briefly discussed.

The Hon. Secretary stated that while the appointment to his office would be made (under Article 41) by the incoming Council, he submitted that the meeting might record its view that owing to the amount of work now required of the Hon. Secretary, the appointment of an assistant Hon. Secretary was desirable. This was unanimously agreed to.

DECEMBER MEETING.

At the Council meeting on 1st December, Professor R. D. Watt, M.A., B.Sc., Dean of the Faculty of Agriculture, University of Sydney, was unanimously elected President of the Institute for 1939. His installation will take place at the conclusion of the forthcoming General Meeting.

MEETINGS OF BRANCHES.

Canberra, A.C.T.

On the afternoon of August 29th, Professor W. H. Britton, Vice-Principal of the Macdonald College, Canada, and Dean of the Faculty of Agriculture there, addressed members of the Branch on " Agricultural Education ". Professor Britton was a foundation member of the Canadian Society of Technical Agriculturists, which is that dominion's opposite number to our own Institute.

The lecturer dealt briefly with types of agriculture in Canada, and contrasted the methods in use there with those in Australia. His main thesis was that agricultural education had to be adapted to the needs of the country concerned. Dealing specifically with Macdonald College, he showed how there has been a very great advance in the last eight years in the courses presented, and in the simplification of these courses.

On September 15th, Mr. J. W. Hadfield, Director of the Agronomy Division of the D.S.I.R., New Zealand, addressed the Branch on the organisation of agricultural research in New Zealand. After outlining the general organisation in New Zealand, he dealt specifically with the work of his own section. The programme of that section was very extensive, but owing to limitations of staff intensive work on all of the phases was not yet possible.

On October 12th, Mr. R. W. Prunster, a member of the Weeds Section of the Division of Plant Industry, C.S.I.R., gave to the Branch an outline of the history of the *Cumbungi* (Bulrush) problem in the Murrumbidgee Irrigation Areas in N.S.W. He pointed out how the depression, leading as it did to a restriction of funds for maintenance work on the canals, had helped in the rapid distribution of the pest in the canal area. He then gave a brief outline, illustrated by lantern slides, of his own work which had led, in co-operation with the Irrigation Commission of N.S.W., to a very good partial solution of the problem.

New South Wales.

The twentieth meeting of the Branch was held in the School of Agriculture, Sydney University, on 21st October. The President, Principal E. A. Southee, occupied the chair. The financial statement disclosed a credit balance of £17 16s. 4d. The Secretary announced that copies had been received of the Memorandum on " Salaries and Status " prepared by Professor Wadham, Federal President, in furtherance of the expressed intention of the Institute to investigate the subject. A copy of the Memorandum has since been forwarded to each member of the Branch.

The main business was an illustrated address by Professor Eric Ashby, Professor of Botany in the University of Sydney, on " Methods and Results in Crop Physiology ". The subject matter of the address will be incorporated in an article in a later issue of the Journal.

At the November meeting of the Branch, a joint discussion took place on " The Effect of Soil Composition on the Nutritive Value of Human and Animal Food ". The discussion was opened by Mr. E. Griffiths, Chief Chemist in the Department of Agriculture, followed by Dr. R. B. Kelley, Officer-in-Charge of the McMaster Veterinary Field Station, and Professor Priestley, of the Medical School, Sydney University.

Queensland.

The July meeting was devoted to an address by Mr. J. H. Smith on " The Influence of Insects on Agricultural Development ", summarised under " Current Notes and News ".

The August meeting was devoted to Notes and Exhibits. Mr. C. R. von Stieglitz dealt with " Soil Sampling Methods ", outlined under " Current Notes and News ". Mr. W. G. Wells illustrated by means of lantern slides the structure of the cotton fibre and explained the results of fundamental work carried out by Balls in Egypt and by various American investigators on the influence of cultural conditions on fibre structure. A description of staple characters, desirable and otherwise, was given, and the method employed by cotton breeders in determining staple length and uniformity was demonstrated.

On the question of the value of frequent tillage, Mr. J. H. Smith drew attention to Keen's contention that, apart from weed destruction and the opening up of undesirable formations, thorough soil cultivation has no marked benefits on crop production under English conditions. The point was raised for discussion by the meeting, because (*a*) sub-soiling and deep ploughing are often advocated in Queensland ; (*b*) under-cultivation is said to be a common fault in farming practice in this State ; and (*c*) cultivation as a means of conserving soil moisture is questioned.

At the September meeting, Dr. A. E. V. Richardson spoke on " The Development of Grasslands ". This address is summarised in the main portion of this issue.

At the meeting held on 24th October, Mr. W. W. Bryan spoke on " The Genetic Approach to Plant Breeding ".

Western Australia.

The August general meeting was devoted to a discussion on " Agricultural Education ", reported under " Current Notes and News ".

The meeting on 7th October was held during the week of the Perth Royal Show. This enabled the attendance of several country members who seldom have the opportunity to attend meetings. A joint meeting was arranged with the Australian Chemical Institute to view films which had been loaned to that body by the Broken Hill Proprietary Ltd., and which showed the activities at the Company's mines at Broken Hill, New South Wales, and the lead smelters at Port Pirie, South Australia.

Tasmania.

In continuance of the series of meetings decided upon at the commencement of the year, a short paper was given by Mr. T. D. Raphael in Hobart on the work being conducted at the horticultural experimental areas.

Owing to varied climatic conditions, it was found necessary to procure suitable areas in three districts. The first of these, at Kettering, is devoted mainly to the culture of bush fruits and nuts, and to general propagation work in apples, etc. The second, at Cambridge, is laid out to stone fruits, and the third, on elevated ground in the Neika area, is entirely devoted to virus and selection work on strawberries. The main problems and lines of approach were fully discussed, and a brief summary of projected work outlined.

Current Notes and News

New Institute of Agriculture, University of Western Australia.

An important step in the progress of agricultural education and research in Western Australia was made on 27th October last, when the new building for the Institute of Agriculture was officially opened by the State Premier (Hon. J. C. Willcock, M.L.A.) in the presence of a large gathering which included representatives of the various branches of the pastoral and agricultural industries.

The building, which cost £14,000, is set on a site of 25 acres in the southern part of the University grounds at Crawley. The money for its erection was provided from University trust funds, but by the passage of a bill through parliament the Government has assumed responsibility for the repayment of this money over a period of years, and the building is therefore, in reality, a gift to the University from the Government.

Mr. A. R. Baxter-Cox was the architect for the work, and was in close collaboration throughout with the Professor of Agriculture (Dr. J. E. Nichols).

Opening of the New Institute of Agriculture, University of Western Australia, by the Premier of W.A. (Hon. J. C. Willcock, M.L.A.).
(Photo by courtesy of the "West Australian".)

The design of the building is based on utilitarian principles. There are basement, ground and first floors, and the pleasing cream brick exterior is surmounted by a roof of red tiles. The basement contains store rooms and constant temperature rooms. On the ground and first floors the rooms, in general, have been designed and fitted so that any or all may be used for either office or laboratory work. Four suites of three rooms are included, made up of two small rooms each connecting with a central large laboratory. There are laboratory benches in all rooms fitted against the large no-draught windows. Balance rooms are provided on both ground and first floors, while the first floor also includes lecture and reading rooms and laboratories for students in agriculture. The Professor of Agriculture and the administrative section are accommodated on the ground floor. With the rooms designed for flexibility, it is hoped that from time to time accommodation can

be arranged for local and visiting agricultural research workers on various problems. Already the Council for Scientific and Industrial Research has indicated its intention of making an officer available for agrostological work in Western Australia.

The development of the Institute grounds for animal and plant experimentation is now proceeding as a result of generous donations from the Commonwealth Bank, the Merino Stud Breeders' Association, Cuming, Smith & Mt. Lyell Farmers' Fertilisers Ltd., the Bank of New South Wales, Dalgety & Co. Ltd., Goldsbrough Mort & Co. Ltd., Elder Smith & Co. Ltd., Westralian Farmers Ltd., and the Pastoralists' Association. Developments include a one-story brick building for animal housing, together with small holding paddocks for stock, and plots for botanical and agrostological studies.

Agricultural Education.

The meeting of the Western Australian Branch held on 5th August was devoted to a discussion on " Agricultural Education ". Professor J. E. Nichols opened the discussion and said that any system of agricultural education must be judged according to how it met the requirements of the four main groups of people directly interested in the industry—the practitioner (the farmer or grazier), the potential practitioner (the young farmer), the extension officer or agricultural adviser, and the investigator. Agricultural education had been regarded as being mostly technical, but the cultural values of the study of applied science could not be denied. It was on the cultural side that agricultural teaching in the primary and post primary schools should be aimed. The attempt should be to create in the child an interest in his natural surroundings, to develop his powers of observation and inquiry, rather than to impart specific agricultural knowledge. Secondary schools and agricultural high schools might go somewhat further, but must not neglect to accompany their application and demonstration work with a sound training in the basic sciences. Agricultural colleges and universities formed a third stage in agricultural education, and it seemed that here some division of interest should take place to obviate a jack-of-all-trades type of training. Scientific progress had been so rapid and extensive of recent years that it was impossible for one individual to encompass a full knowledge of all the branches of science and their application to agriculture. The test of both purpose and procedure in any system was performance, judged from the viewpoints of cultural value and technical efficiency. Technical education was the acceptance of other people's experience, and agricultural education should aim to do more than this ; it should project the mind forward and keep it flexible to adapt itself to new knowledge and experience.

Mr. H. J. Hughes (until recently Principal of Muresk Agricultural College) spoke more specifically of the organisation of agricultural colleges in Australia. A reasonable educational entrance standard was necessary. he said, to avoid retarding the already well-trained for the benefit of those of lower standard. He believed that an intimate association with the practical work at the college helped to develop a love of the country in boys while at an impressionable age.

Mr. W. Southern (recently appointed Principal of Muresk Agricultural College) outlined his experiences in teaching agricultural science in secondary schools to students of Junior and Leaving Certificate standards.

Mr. Murray Little (Chief Inspector of Schools) emphasised the importance of interesting country children in their environment. The vast majority of them were destined to become practitioners, and hence a good country teacher should try to bring farm and school together. He must engender in his pupils while young an interest in agriculture and provide scope for the expression of that interest as they grew older.

In the discussion which followed, Dr. T. C. Dunne asked why sons of good farmers usually went to secondary schools in the city rather than to agricultural colleges. Dr. G. L. Sutton suggested that the probable reason was because the most important phase

in successful agriculture was administration, and for this the first essential was a good general education. It allowed full development of the individual and further fitted him to take his rightful place in the community. A good general education seemed the ideal basis for a sound agricultural training.

Soil Survey of S.E. Forest Areas in South Australia.

At the October meeting of the Agricultural Sciences Club, Waite Research Institute, Mr. C. G. Stephens, of the Soils Division, C.S.I.R., gave a progress account of recent soil survey work in the south-eastern forest areas of South Australia.

The field and laboratory work on the Mt. Burr and Mt. Gambier pine forests, which aggregate about 37,000 acres, has almost been completed and a start has been made with the survey of the 22,000-acre Penola forest.

The soil types on the completed areas have been mapped in phase detail, and the types have been named as follows: Young Sand, Mt. Burr Sand, Mt. Muir Sand, Hindmarsh Sandy Loam, Riddoch Sand, Tantanoola Flinty Sand and Wandilo Sand. The first three are derived from the æolian sands of the area, and present a catena of soil types which—in passing from the Young Sand to the Mt. Muir Sand—goes through a decreasing degree of podsolisation. The Young Sand is a humus hardpan podsol. The Hindmarsh Sandy Loam is situated directly on the Recent and Pleistocene limestones of the area, and its characteristics strongly suggest that it is a *terra rossa*. The remaining soil types, which are situated in lower lying localities, are planted to only a small extent, and have been regarded in the past largely as pastoral soils; they are essentially meadow podsols. However, the growth of *Pinus radiata* on these soils is such that there must be, in future, keen competition for them by the forest authorities.

Provided certain factors, such as management, are constant over an area, then there is a distinct association of tree vigor and soil type. In this respect the trees on the Young Sand are poor. Also the incidence of dieback disease is rather strongly associated with the Mt. Burr Sand, being generally less on the Young Sand, the Mt. Muir Sand and the Hindmarsh Sandy Loam. The disease is virtually absent on the Riddoch, Wandilo and Tantanoola soil types. There is also a distinct correlation of tree type—hence timber quality—with soil type. Certain small areas of basaltic soil which have been planted are producing fast growing, highly tapered, heavily limbed trees, and although the yield per acre will be high there will be a great proportion of second grade timber.

The successful utilisation of the Mt. Burr Sand, which is the most extensive and important soil type so far mapped, among those used for growing *Pinus radiata*, depends largely on the degree of management. Factors which enahnce the growth of the trees and reduce the incidence of dieback on all phases of this soil type are: (1) control of re-growth of native vegetation, (2) old pastoral sites, and (3) cultivation with the plough instead of pitting at the time of planting.

Soil Sampling Methods.

At the August meeting of the Queensland Branch of the Institute, Mr. C. R. von Stieglitz summarised the results of a recent study of soil sampling methods conducted by the Bureau of Sugar Experiment Stations. To correlate field results with laboratory determinations, the soil sampling technique must be standardised, and it seemed that the sample taken immediately prior to or immediately after harvesting the first crop would represent an average sample for the ordinary rotation.

In determining a standard sampling procedure, consideration was given to (*a*) influence of the cropping history of the block; (*b*) optimum number of borings per unit area; (*c*)

position in field with respect to plant rows ; (*d*) depth of soil which should be sampled in respect of available plant foods.

Results showing the effect of cropping history were given. In the case of two 5 × 5 latin square farm fertility trial sites at Mackay and Cairns, samples were obtained from permanent locations in each of three successive years. On the five unfertilised plots at Mackay, the amounts of available P_2O_5 (p.p.m.) from four samples on each plot were : (20, 40, 26, 25) ; (17, 25, 30, 26) ; (23, 35, 11, 23) ; (92, 112, 43, 53) ; (50, 35, 51, 45)—average, 40 p.p.m. Similar results were shown in the next two years, averaging 39 p.p.m. and 40 p.p.m. (first year sampling at end of first plant period, second year at end of first ratoon, third year after fallow).

Replaceable potash figures for Mackay (in *Ways*—i.e. mill equivalents per 100 grammes) were in one year as follow : (20, 24, 23, 17) ; (21, 22, 26, 27) ; (25, 29, 24, 25) ; (28, 31, 29, 27) ; (23, 17, 17, 21). Averages for three years : 24 Ways, 13 Ways and 20 Ways. The content of replaceable potash did not vary at any one sampling period as much as the available P_2O_5.

pH values (KCL) varied very little over the three years.

Similar results were secured at Cairns.

In addition, ten borings were made at random from each of three fields on three farms on three soil types, the crops receiving the standard fertiliser treatment for the area. The ten borings were found insufficient to give a representative sample.

Influence of Insects on Agricultural Development.

An address on " The Influence of Insects on Agricultural Development " was given by Mr. J. H. Smith to the Queensland Branch of the Institute on 29th July, the essentials of which are summarised below :

Agricultural pioneers first selected the more accessible areas for exploitation if soils and climate appeared satisfactory. Experience gained chiefly by trial and error methods kept losses equally with gains within reasonable limits until prospects could be examined with some accuracy. Even now it is unlikely that the balance of crop interests in any young State will be permanent. Changes must inevitably occur, particularly in Queensland, a tropical and sub-tropical State which has been developed by a people with traditions associated with temperate agriculture. Insects have played, and will continue to play, a part in such changes.

A pest problem may unwittingly be created by normal agricultural progress. Indigenous Scarabs have only become a problem in pastures during recent years, a phenomenon due in part to a decline in soil fertility and in part to ecological changes favourable for such pests. The losses caused by white grubs, the larvæ of these Scarabs, point to the limitations of the soils in which they are troublesome, and place a premium on the efficient farming methods by which they may be kept in check—if not entirely overcome.

Insects may determine the location of a primary industry. In Queensland, deciduous fruits are grown commercially chiefly at Stanthorpe. Attempts to grow them elsewhere, where soil and climate appear more or less suitable, have seldom been profitable primarily because the Queensland fruit fly—the bugbear of deciduous fruit growers in the State—takes a heavy toll of the crop. Is it too much to suppose that, were fruit fly less destructive, the commercial production of at least some deciduous fruits would be practicable, for example, on the Darling Downs ?

Though insects play a large part in the economy of almost any cultivated crop, and have, therefore, been studied in great detail, entomological forecasts which may influence developmental policy can seldom be given with any certainty. Thus the Mediterranean

fruit fly, a widely distributed and closely investigated pest, occurs in Australia without assuming any great importance in the eastern States, though it is very destructive in Western Australia. Scientifically, there is no apparent reason why the insect should not play havoc in fruit growing areas in Queensland and New South Wales, and anticipations of such behaviour could have been proffered some years ago.

Thus agricultural development will be primarily controlled by climate and soil. Insects may limit production and define the location of an industry. They may also stimulate improved farming practices. The entomologist can only modify trends so that land may be profitably farmed with a minimum of adversity.

Conference of Seed Testing Officers.

The third Interstate Conference of Seed Testing Officers was held at the Department of Agriculture, Sydney, on October 11th, 12th and 13th. The Conference was officially opened by Major the Hon. A. D. Reid, M.L.A., Minister for Agriculture, N.S.W.

Delegates from all States attended the conference, those present being: Dr. B. T. Dickson, Division of Plant Industry, C.S.I.R.; Messrs. Ewen Mackinnon, Commonwealth Department of Health; J. N. Whittet, N.S.W.; C. Bartels, Victoria; F. B. Coleman, Queensland; E. W. Pritchard, South Australia; G. R. W. Meadley, Western Australia; and A. H. Woodford, Tasmania. Misses Myers, Little and Ross, of the Agrostologist's Branch of the N.S.W. Department, were also in attendance.

Addresses were delivered by Mr. J. N. Whittet and Dr. H. J. Hynes. Mr. Whittet spoke on " Some impressions gained during a recent visit to European, British and American seed laboratories ", while Dr. Hynes addressed the delegates on " Some biological aspects of defective germination in culinary peas ".

Mr. G. Yates attended one session of the Conference, presenting the case of the N.S.W. seed trade in respect of the operations of the Federal Quarantine Act. He suggested certain alterations to the schedule of noxious and other weed seed impurities.

Considerable time was given to the discussion of the technique of methods of seed testing, and the standards for purity and germination of agricultural seeds were reviewed.

Among other matters dealt with were consideration of (*a*) the reliability of the fluorescence test for *Lolium perenne* and the picric acid test for *Trifolium repens*, (*b*) abnormal growths in Cruciferæ, (*c*) the operations of the Federal Quarantine Act (Plants) and the Commerce Act, (*d*) uniformity in administration of the State Agricultural Seed Acts.

Amongst a number of resolutions which were submitted to the Conference by Mr. Whittet and carried unanimously were:

(1) That the Commonwealth and State Governments be asked to provide sufficient funds to enable an Australian delegate to attend the International Seed Testing Congress which is to be held at Washington, D.C., United States of America, in May, 1940.

(2) That consideration be given to the licensing of approved commercial seed testing laboratories, as is done in Great Britain.

Agricultural Sciences Club, S.A.

A meeting of the Waite Agricultural Sciences Club was held on 25th August, 1938, in the lecture room of the Ranson Mortlock Laboratory.

Miss J. McNeil gave an address on " Mycological Studies on Oranges ", an account of preliminary work carried on in the investigation of the problem of storage spot. The mycological condition of fruit from experimental plots at Mypolonga, Waikerie and Berri was examined. After stringent surface disinfection, isolations made from the rind of apparently sound oranges revealed the presence of a variety of fungi, presumably present within the rind as " latent infections ". The predominant fungal genus was *Colletotrichum*,

while other noteworthy forms were *Septoria* and the *Alternaria-Macrosporium* group. Direct microscopic evidence of " latent infections " was obtained by cutting and differentially staining microtome sections of the rind, when fungal mycelia were observed occupying the lower of the epidermal and underlying cells.

In a paper entitled " Expectation of Rainfall ", Mr. E. A. Cornish outlined a statistical method designed for determining the quantile points of the skew frequency distribution of rainfall. The method was illustrated with the rainfall data of Yudnapinna and Birdsville, each centre showing a strong positive skewness in the frequency distribution of rainfall, which prevented the use of ordinary methods based on the normal distribution.

Messrs. D. S. Riceman and C. M. Donald spoke on " Copper Deficiency in Plants ". The paper dealt with the occurrences of copper deficiency recorded throughout the world and the symptoms in the various plants affected. A comparison was made of the various soil types concerned and a contrast was drawn between the highly calcareous soil on which copper deficiency occurs in South Australia and the organic soils affected in Europe and America. Knowledge of factors affecting copper availability was reviewed and the necessity of copper in chlorophyll formation and in the functioning of the generative organs was discussed.

Melbourne University Agricultural Society.

At the meeting of the Society on 26th August, papers were presented by Messrs. R. A. Maher and R. D. Croll.

Mr. R. A. Maher spoke on the " Production of Cruciferous Crops ", dealing mainly with the areas of production, climatic and soil requirements, seed bed culture, planting, management, harvesting, insect pests and diseases. He considered that the export to the near East of cruciferous crop products was a possibility. He also stated that scientific investigation to aid this industry would probably be most fruitful if conducted along the lines of strains and manurial requirements.

Mr. R. D. Croll, in discussing the " Clay Complex ", stressed the importance and lack of knowledge of the clay minerals. Mattson's view of the clays as being amorphous bodies of indefinite constitution was contrasted with the opinion of Marshall and others who look upon the clay complex as composed of a few crystalline minerals of definite composition. Recent X-ray work so far favoured the latter view. Mr. Croll discussed in some detail this more recent work on the structure of the clay minerals and also the significance of the silica-sesquioxide ratio, and pointed out that the correlation of soil properties with this ratio may not, in many cases, be valid. (Attendance, 50.)

On 9th September, Miss Lorna Byrne, Organiser of the Women's Section of the Agricultural Bureau of New South Wales, addressed the Society on " Extension Work by the N.S.W. Department of Agriculture and other Countries ". Miss Byrne described the systems in operation in the various countries visited recently, and commended many points for consideration in Australia. Of particular interest was the high degree of co-operation in Scandinavia whereby a farmer kept his costs down to a minimum, the high education standard of the average farmer in Denmark, the training of women in Sweden who later went out and gave practical advice individually or in groups to womenfolk on farms, and the great number of schools for old and young in Russia. The extension services in the United States and Canada were somewhat similar to those in New South Wales, where the extension officer resided in the country, kept in direct touch with the farmer, and maintained contact with the controlling body—the Department of Agriculture. A recent development in N.S.W. had been the holding of camps for girls for training in leadership, public speaking, physical culture, etc. Miss Byrne considered there was a need for trained economists and sociologists, as well as agriculturists, to go out among farmers. (Attendance 40.)

On 7th October, Mr. C. J. Pemberton, Superintendent of the Vermin and Noxious Weeds Branch of the Victorian Lands Department, addressed a combined meeting. Mr. Pemberton traced the development of the present Vermin and Noxious Weeds Act and described its administration. In other States, the responsibility for enforcing the pro-provisions of the Act was vested in shire or county councils or roads boards, but in Victoria the whole expenditure of administration, which was approximately £138,000 per annum, was met by the government. Generally speaking, vermin were easily handled, but weed control presented the major problem. After giving a brief description of the six most serious weeds in Victoria, viz. St. John's Wort, Ragwort, Hoary Cress, Blackberry Bramble, Cape Tulip and Californian Thistle, and their known methods of control, Mr. Pemberton indicated the measures taken by his Branch to prevent the introduction of weeds from other States and from overseas. (Attendance 44.)

Address by Dr. Callaghan on South Africa.

At the September meeting of the South Australian Branch of the Institute, Dr. A. R. Callaghan gave an address on impressions gained during his recent visit to South Africa as leader of a goodwill tour. The itinerary of the tour was described, and observations on the agriculture of the country were given as the description proceeded. Two outstanding factors which influenced the technical and economic position of the pastoral and agricultural industries were the dependence of the country on gold, and the abundance of cheap native labour. Mineral wealth permitted a heavy subsidisation of agriculture, which, however, tended to be inefficiently practised. Liberal government assistance had tended towards a certain amount of wastefulness in expenditure, resulting in overcapitalisation of holdings, unnecessarily expensive structural improvements frequently being seen. Livestock, on the whole, were of poor standard, and there appeared to be little knowledge of modern principles of grassland improvement.

A. W. Howard Memorial.

At a public meeting recently held at Mount Barker, S.A., it was decided to establish a memorial to the late Mr. A. W. Howard, who first demonstrated the value of subterranean clover. A committee has been formed to launch an appeal for funds, with which it is hoped to create a permanent trust, with the following objectives: (1) the establishment of demonstrational plots relating to clover culture, and (2) the award of a suitable scholarship at some appropriate institute of learning. Donations are being received by the Secretary, Howard Memorial Committee, P.O. Box 60, Mount Barker, S.A.

Book Reviews

STATISTICAL TABLES FOR BIOLOGICAL, AGRICULTURAL AND MEDICAL RESEARCH, by R. A. Fisher, Sc.D., F.R.S., and F. Yates, M.A.

(Pp. viii+90, with 34 tables. Oliver and Boyd, London and Edinburgh, 1938. English price, 12/6.)

This valuable book forms a companion volume to the statistical works already published by these well known authors. It may be stated at once that the high standard set in the past has been maintained in the new volume.

The first 22 pages are devoted to an explanation of the construction and use of the tables illustrated with the numerical details of 16 examples. The introduction concludes with a neat section on interpolation.

The majority of workers in Australia are already familiar with Tables I and III to VII, which have been taken from Fisher's *Statistical Methods*. In their new form, all tables except I have been enlarged. In Tables III (t), IV (χ^2), V (z and the variance ratio, e^{2z}) and VI (interclass r), tabular entries have been included corresponding with an extension in the range of probabilities to $P=0{\cdot}001$, and V contains, in addition, $P=0{\cdot}2$. Again, in Tables III and V tabular values have been added corresponding with an increased range of degrees of freedom. This feature greatly facilitates the operations of interpolating in these tables.

Table II gives the ordinates of the normal distribution.

Table VIII provides the special material needed in making tests of significance for 2×2 contingency tables.

Table IX gives the normal deviate corresponding with each thousandth of the whole population, which is exceeded by any given frequency. The numbers (probits) tabulated are of special form to facilitate standard methods of calculation. Table X, simple quantiles of the normal distribution, gives the deviates corresponding with proper fractions. This table is of value in finding probits when small numbers are involved. Table XI provides weighting coefficients and probit values to be used in adjusting the coefficients of the provisional regression line for such refined purposes as tests of significance.

Tables XII to XIV constitute a group giving the transformation of a fraction, p, to an angle φ, according to the relation

$$p=sin^2\varphi.$$

As p varies from 0 to 1, φ varies from 0° to 90°. Not infrequently an analysis of variance of a set of percentages or fractions is needed, but the variable as it stands is unsuitable, since the variance alters over the range 0-100 per cent. The above transformation stabilizes the variance, and the angle provides a suitable variate for analysis.

Table XV gives examples of Latin squares up to size 12×12, from which experimental arrangements may be constructed using the randomization procedure described in the introduction, while Table XVI gives exceedingly useful complete sets of orthogonal Latin squares of sides 3 to 9. The utility of such squares has been described in *The Design of Experiments* and in *The Design and Analysis of Factorial Experiments*.

Tables XVII to XIX deal with the recently devised method of balanced incomplete blocks, giving solutions of this experimental arrangement over a wide range of treatments, number of blocks, units per block and number of replications. Many workers will find the introductory notes on incomplete blocks of considerable service as Yates' original paper is not readily available in Australia.

Table XX gives the scores to be assigned to a number of magnitudes arranged in order, in samples up to size 50, when their quantitative values are unknown. After assigning the appropriate scores, ordinary statistical tests may be made, e.g. an analysis of variance may be performed on the allotted scores. Table XXI gives the sums of the squares of individual scores. The scoring of ties and the necessary adjustments to the sums of squares are explained in the introduction.

Table XXII gives the leading differences of powers of the natural numbers. These are particularly useful in combinatorial problems.

Table XXIII has been designed to expedite the fitting of orthogonal polynomial regression lines. The process of fitting by the method of successive addition has been described in detail in *Statistical Methods*, but since this procedure is not always the most convenient, a new table has been specially constructed for use with a calculating machine capable of multiplying. Instead of tabling the ξ's, which are not always whole numbers multiples of the ξ's, $\xi'=\lambda\xi$ have been tabled. In each case the smallest value of λ is chosen which gives integral values to ξ'. Table XXIII shows the numerical values for all ξ' from ξ_1' to ξ'_5 and all n' from 3 to 52, together with λ and the sum of the squares of each set of ξ''s.

Table XXIV gives some very useful formulæ for the calculation of integrals from equally spaced ordinates.

Tables XXV to XXXII form a set of standard functions of general use. Special mention may be made of table XXVI, 5 figure natural logs, Table XXVII, exact squares of all 3 figure numbers on two face pages and Table XXVIII, square roots so tabulated that the root of each 3 figure number and ten times that number appear together.

Table XXXIII is a set of random numbers and Table XXXIV is a collection of constants, conversion factors, etc.

In the selection, form and presentation of the tables, of which several are not available elsewhere, one can recognize the mature experience of the authors, who state in their preface " the main work has been to complete the tables in a form suitable for the general user ". Throughout the book the reader will find evidence of the successful accomplishment of this objective. Most of the tables are provided with facilities for rapid and accurate interpolation, and where these are not given linear interpolation is generally sufficient. No effort has been spared to ensure that the design of each table is such as to render it capable of expeditious use, e.g. Tables I, IX and X all give similar information about the normal distribution, but each is of different construction specific for a definite purpose.

In spite of the care exercised by the press, two minor misprints found their way into the book. On page 14, fourth line from the top, the exponent of p should read $n-r$, and on page 17, fifth line from the top, ξ_2 should read ξ'_2. Nevertheless, the publishers have contributed a very creditable share in the production of the tables.

E. A. Cornish.

PHYTOHORMONES, by F. W. Went, Ph.D., and Kenneth V. Thimann, Ph.D. (Pp. xi+294, with 62 figures and 16 tables. New York: The Macmillan Company, 1937. Price, 4.00 dollars.)

The literature on plant hormones has assumed such proportions within recent years, that it has become difficult for persons not directly interested in the subject to keep in touch with the work and secure a clear picture of what has been accomplished. Consequently, a book such as this will be welcomed not only by those actively engaged in work on plant hormones but also by all whose interest has been aroused by the numerous articles on the subject in current plant physiological and biochemical literature.

The volume follows little more than a year after the translation by Avery and Burkholder of Boysen Jensen's book on the same subject, but the authors claim that their book is not superfluous. They state that the aim of their book is to analyse and integrate knowledge of the subject rather than merely to review past work.

The introductory chapter outlines the scope of the book, discusses definitions, and gives a list of previous reviews in this field. The succeeding chapters are concerned with the development of the hormone concept; the technique of auxin determinations; formation and occurrence of auxins; the relation between auxin and growth; auxin transport and polarity; the chemistry of the auxins; the mechanism of the action; the growth of roots; tropisms; root formation; bud inhibition; other activities of auxins; and general conclusions.

In Chapter II, the authors have shown in an interesting manner how four apparently independent lines of plant physiology, namely organ formation, correlation, tropisms and growth have been gradually brought together by the discovery of the functions of hormones. For those who contemplate experimental or investigational work with plant hormones, Chapter III, on the technique of auxin determination, should be particularly useful. In the final two chapters, which should be of interest to all readers, the authors discuss a wide range of subjects with which plant hormones are directly and indirectly connected.

The reader who is interested mainly in the practical applications of plant growth substances in horticulture and agriculture may be disappointed in the relatively small amount of space allotted to this aspect of the subject.

The list of literature references covers 33 pages, whilst there are useful indexes to authors and subject matter.

The authors have attempted a somewhat difficult task in that many new contributions on plant hormones are appearing each year, and there are still many phases of the question which await final settlement. However, they have given not only an excellent survey of the literature, but have also attempted to bring some order from the mass of data which has accumulated.

R. D. Wilson.

PLANT GROWTH SUBSTANCES: THEIR CHEMISTRY AND APPLICATIONS, WITH SPECIAL REFERENCE TO SYNTHETICS, by Hugh Nicol.

(Pp. xii+108, with six figures and numerous formula diagrams. London: Leonard Hill Ltd., 1938. Price 3/6.)

This book is a compilation of information concerning natural and artificial growth substances, their synthesis, identification, classification, nomenclature, method of use in practice, and effect on the plant. Much of this field has already been covered in the book of Went and Thimann. Dr. Nicol writes frankly from the point of view of a chemist, although intercalated among the descriptive chemistry are reviews of physiological work.

The harmony of an otherwise esoteric book is disturbed by the writing of the first two chapters for the layman. The style of these chapters would have been improved by the omission of the sops to the layman's supposed level of intelligence and humour: in the opinion of the reviewer, science should be rendered sufficiently appealing to the layman by the revelation of its intrinsic fascination. One welcomes, nevertheless, Dr. Nicol's stress on the practical importance of scientific work that has been pursued without utilitarian aims; too much propaganda cannot be devoted to making the value of such work appreciated by the layman.

The most useful and fertile chapter in the book is perhaps that dealing with the occurrence of growth substances in soils and manures. This chapter adds to the value that the work will have for a certain audience: this audience will embrace agricultural scientists who are not actively working on growth substances, but who are anxious to obtain a general knowledge of the facts so far discovered about them.

While Dr. Nicol's book will undoubtedly prove a useful review to many such people, one hopes that no more books will be written on growth substances until more is known about their real biochemistry. There is a field of biochemistry, much removed from that which is purely descriptive and systematic, that is concerned with the chemical processes occurring in the plant cell. Knowledge in this field is increasing slowly along various independent paths, but one still awaits the appearance of books devoted to the integration of the knowledge obtained along these paths and the formulation of new and unified points of view. Is it too much to hope that the next book might be on plant growth, in which the growth substances are dealt with in their proper setting and perspective?

A. H. K. Petrie.

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Personal Notes

New South Wales.

Dr. R. H. Carr, Professor of Agricultural Biochemistry at Purdue University, U.S.A., is visiting Australia for the A.N.Z.A.A.S. meetings to be held in Canberra in January, 1939. He recently visited the School of Agriculture, Sydney University, and the State Department of Agriculture.

A symposium on " Parasitism " was held at the September meeting of the Biological Society, Sydney University. The speakers were Professor Harvey Sutton, Dr. R. J. Noble and Messrs. A. R. Woodhill, A. N. Colefax and H. M. Gordon.

Mr. C. James, formerly Lecturer in Biology at the Armidale Teachers' College, has been appointed Headmaster of the Farrer Memorial Agricultural High School, Tamworth.

Mr. W. S. Sutton has returned from a month's visit to the Dairy Research Institute, Palmerston North, New Zealand, where he studied the technique of investigating bacteriophage in cheese starters.

Mr. H. I. Williams has been appointed Agricultural Editor of the " Sydney Morning Herald ", in succession to Mr. P. G. Gilder, retired.

South Australia.

Professor J. A. Prescott has been awarded the Sir Joseph Verco Medal of the Royal Society of South Australia, in recognition of his distinguished scientific work as a member of this body. The medal was presented by His Excellency the Governor at the November meeting of the Society.

Dr. J. G. Davies has resigned from the staff of the Waite Institute to accept the position of Senior Agrostologist in the Division of Plant Industry of the Council for Scientific and Industrial Research. At the request of the State Committee in Western Australia, Dr. Davies left by air on 11th October to conduct a survey of the grasslands of that State.

Mr. J. K. Taylor, Senior Soil Surveyor of the Soils Division, C.S.I.R., will sail for America on 3rd January next. He proposes to spend a short period in California and will then travel through various centres to Washington, which will be his headquarters for about three months. He will return via England, after an absence of approximately twelve months.

Mr. T. J. Marshall, of the Soils Division, C.S.I.R., returned to the Waite Institute in October, after an absence of two years, during which he was engaged in post-graduate studies on methods of soil examination at the University of California.

Sir John Russell, who will attend the Science Congress at Canberra in January, is due in Adelaide on 17th December, and will spend a few days as the guest of Professor Prescott before proceeding to Brisbane and Canberra.

Western Australia.

Dr. E. J. Underwood, Animal Nutrition Officer of the Department of Agriculture, returned to Perth on 14th November after an absence of two years. During that period he was the holder of a Commonwealth Fund Fellowship and worked at the University of Wisconsin, Madison, U.S.A., on animal nutrition problems. He travelled extensively in U.S.A. and also visited Canada, England, Scotland and South Africa on the return journey.

Mr. W. Southern was appointed, during September, to succeed Mr. H. J. Hughes as Principal of the Muresk Agricultural College. Mr. Southern graduated B.Sc. (Agric.) at the University of W.A. in 1928 and obtained the Diploma of Education in 1934. He has had extensive experience of both farming and teaching and, for the past ten years, has been a master at Wesley College, teaching science and agricultural science subjects.